Strengthening Pest Control Operations of Plant Protection Directorate for Improved Protection of Migratory Soaring Birds in Sudan

Summary

In Sudan pesticides are managed by Pesticides and Pest Control Products Act 1994 which replaced the Pesticides Act of 1974. The act regulates all activities related to pesticides registration, importation, storage, transportation, use, formulation and any other related activities in the country through the National Pesticides Council (NPC). The registrar of the council is the Director General, Plant Protection Directorate (PPD). The PPD is responsible for implementation of Phytosanitary procedures and legislations to safeguard export and import plant commodities from pests and diseases and with direct supervision of all Phytosanitary activities at all entry points and ports of States in the Sudan. The PPD also is responsible for the survey and control operations of national pests including locusts, quelea birds, dura andat (sorghum bug), rodents and date palm green scale insect, fruit fly and water hyacinth weeds, in additional to other seasonal and invasive pests in irrigated and rain fed schemes. Reasonable use of the pesticides (insecticides, rodenticides, avicides, herbicides and pheromone) applied to manage these pests can lead to indirect poisoning of migratory soaring birds that visit the country during October to March. To avoid and reduce these limited risks due to misapplication the PPD need to increase the awareness of their staff through continuous intensive training in integrated pest management (IPM) programs to conduct the different operations safely and effectively according to the legal framework regulating the pesticides use in Sudan.

Introduction

The pesticides use in Sudan started in 1949 with the introduction of the chlorinated hydrocarbon DDT for the control of cotton jassid (*Jacobiasca lubica* deBerg) in Gezira scheme. This followed by the introduction of the organophosphate compounds, namely parathion in early 1950s and became a reliable partner to the organochlorines for the control of the complex of chewing and sucking insect pests, when dimethoate was first used in 1960/61 season. By the mid-1970s cotton production was no longer economically viable because of emerging outbreaks of pesticide-resistant whitefly populations. The number of applications during the season has also risen to levels to average 9-11. Early 1980s the problems from the increased use of pesticides cause change in the cotton pest's complex and led to the introduction of synthetic pyrethroids.

In the 1990s the integrated pest management programs were developed as crop protection strategy and many attempts were made to reduce the use of pesticides. It relies more on non-chemical means of crop protection on biological control of African bollworm, *Helicoverpa armigera* and higher economic damage threshold levels, permitting a reduction in pesticide application frequency to three per season without yield reduction (Bashir *et al*. 2003). New products less toxic include the Bt toxins, the neonicotinoid imidacloprid, and the phenylpyrazole, fibronil were introduced and in 2010 the genetically modified cotton varieties were registered. Moreover, the rodenticides, avicides and insecticides used reasonably to control desert locust, quelea birds and rodent are conducted when outbreak of these pests are observed. Extensive and intensive use of pesticides occurs throughout the country, resulting in unnecessary contaminating of the environment thereby increasing risks to non-target organisms (birds) (Van Der Sluijs, *et al*. 2014).

The majority of the imported chemicals are used in the agricultural sector specially the irrigated schemes in central Sudan. Cotton (47% of annual import) is the major crop receiving most frequent spray followed by, vegetables (26%), sugarcane (15%), national pests (Plant Protection Directorate (PPD), 7%) and public health sector (2%). Spraying of cotton, sugarcane, and wheat (especially in irrigated schemes) is under the direct control of Crop Protection Sections (CPS) of the Irrigated Schemes & Sugarcane Corporations. However minimum governmental supervision is given to spray operations in vegetable crops, which received an increased importance in recent years (Abdelbagi, *et al*).

Plant Protection Directorate (PPD)

The Plant Protection Directorate (PPD) is mandated mainly to survey and control both national and seasonal invasive pests including locusts, quelea birds, dura andat (sorghum bug), rodents, date palm green scale, fruit fly and water hyacinth weeds, in additional to collaboration and cooperation with unions of farmers to control other seasonal and invasive pests. Moreover, PPD manages and supervises the plant quarantine activities in all stations over the country and implementation of the legislative law through registration, approves importation, inspection and safety use of pesticides. Together PPD Head Quarter with States plant protection departments all efforts are integrated to combat plant pests under Economic Threshold Level (ETL).

Objectives of establishment of the Plant Protection Directorate

1. Planning, execution and follow up of national migratory pests' mainly by systemic operations of survey and control to both national pests including (desert locusts, harmful birds, dura andat (sorghum bug), rodents, date palm green scale, fruit fly and water hyacinth weeds) and seasonal invasive pests.
2. Monitoring and evaluation of pests control operations and their effect on non-target organisms (e.g. birds) after each treatment and collected samples from soil and plants for the residual analysis in the States.
3. Provision of pesticides for the control of national and local pests and supervising of aerial and terrestrial spraying control.
4. Implementation of legislative laws to prevent pest's infestation.
5. Implementation of Phytosanitary legislations to safeguard export and import plant commodities from pests and diseases.
6. Implementation of pesticides and pest's control products legislation.
7. Cooperation and coordination with different international and regional organizations and institutions in all activities of plant protection.
8. Periodical programs of long and short training to the technical staff.

The PPD consists of seven administrative departments:

1. **Pests control department:** responsible for technical supervision of pest's situation including survey and control of pests such as quelea birds, dura andat (sorghum bug), rodents, date palm green scale, fruit fly and seasonal invasive pests in coordination with the operations administration.
2. **Plant quarantine department:** supervision of all Phytosanitary procedures of exports and imports of plant materials at all entry ports of the Sudan and between the States (Interstate Quarantine).
3. **Pesticides department:** responsible for pesticides specifications, and inspection, safe use and registration of pesticides section, the later role as secretary body of the National Pesticides Council to implement registration of pesticides in the Sudan.
4. **Operations department:** executes all control operations and responsible for the logistics, financial and administrative aspects in PPD.

5. **Aquatic and terrestrial weeds department:** survey and control the aquatic weeds and prevent its spread North of Jebel Awlia dam. The administration also surveys and controls weeds.
6. **Locust control department:** responsible for technical supervision of locust situation including survey and control of desert locust, tree locust and grasshoppers *etc.* in coordination with the operations administration.
7. **Technic Transfer's & information department:** executes all modern technology of aerial and terrestrial spraying operations, electronic network reporting system and also responsible of spraying equipment's calibration, economic evaluation of pest control operations and implementation of strategic integrated pest management aspects.

Table 1: Pest Control Campaigns Programs

Activity	**Period**	**Comments** (Effect on MSB)
Desert locust control campaign (aerial & ground)	Jan-Dec	Low risk
Tree locust control campaign (aerial & ground)	Jul-Oct	Low risk
Migratory locust control (aerial and ground)	Jul-Oct	Low risk
Grasshoppers (aerial and ground)	Jul-Oct	Low risk
Dura andat (sorghum bug)	Jan-Jun	Low risk
Rodents treatment in irrigated & rain fed schemes	May-Jul Dec-Jan	Nil risk
Quelea birds (aerial application)	Sept-Nov	low risk
Local birds (mechanical application)	Jul-Nov	Nil risk
Date palm green scale control (soil treatment)	Nov- Dec Feb-Apr.	Nil risk
Fruit flies (pheromone and nutrition baits)	Jan -Dec	Nil risk

Source: Annual Report of Plant Protection in Sudan 2021.

Recommendations to reduce risk of highly hazardous agrochemicals poisoning migratory birds

Obsolete pesticide stockpiles in Sudan:

Sudan has exceptionally large stockpiles of obsolete pesticides that are stored in very hazardous conditions across the country. A preliminary inventory by the Plant Protection Directorate (PPD) in the early 1990s estimated the expired stock at 760 tons and 548 m^3 of contaminated soil (FAO 1995). A survey completed in 2006 under a GEF-Pop's project found this stock to have increased to 1,200 tons of obsolete pesticides and 16,000 m3 of contaminated soil. These figures do not include several hundred tons of expired dressed seeds and containers. Moreover, the survey only covered some of the provincial capitals in Darfur and Southern Sudan and is therefore incomplete for those regions. UNEP visited four stores where large stocks of expired chemicals were kept, including Hasahesa and Barakat (Gezira scheme), El Fao (Rahad scheme) and the Gedaref PPD store. In addition, a visit to the Port Sudan commercial harbor revealed a large stock of expired pesticides and other chemicals. While storage conditions were overall poor, three sites in close proximity to inhabitations (Hasahesa, El Fao and Gedaref) were considered dangerous toxic hotspots.

A stockpile management plan can be required as a condition of authorization to demonstrate how stockpiles are being managed, with the aim of preventing unauthorized stockpiling of materials and preventing or minimizing environmental harms.

Table 3: Recommendations to manage and prevent the stockpile

Lead institution responsible to effect the changes	**Requires change of practices**	**Requires legislative changes**	**Recommendations**	**Problem/Risk to birds or weak procedural areas**
PPD departments (pesticides, safe use of pesticides) and National institutes	conventional pesticides can be replaced by more modern ones more selective, less dangerous to human beings and animals. All pesticides should be provided with material	Yes	Make development of a stockpile management plan a condition of authorization (for importation?)	Unauthorized stockpiling of materials that brings about environmental damage

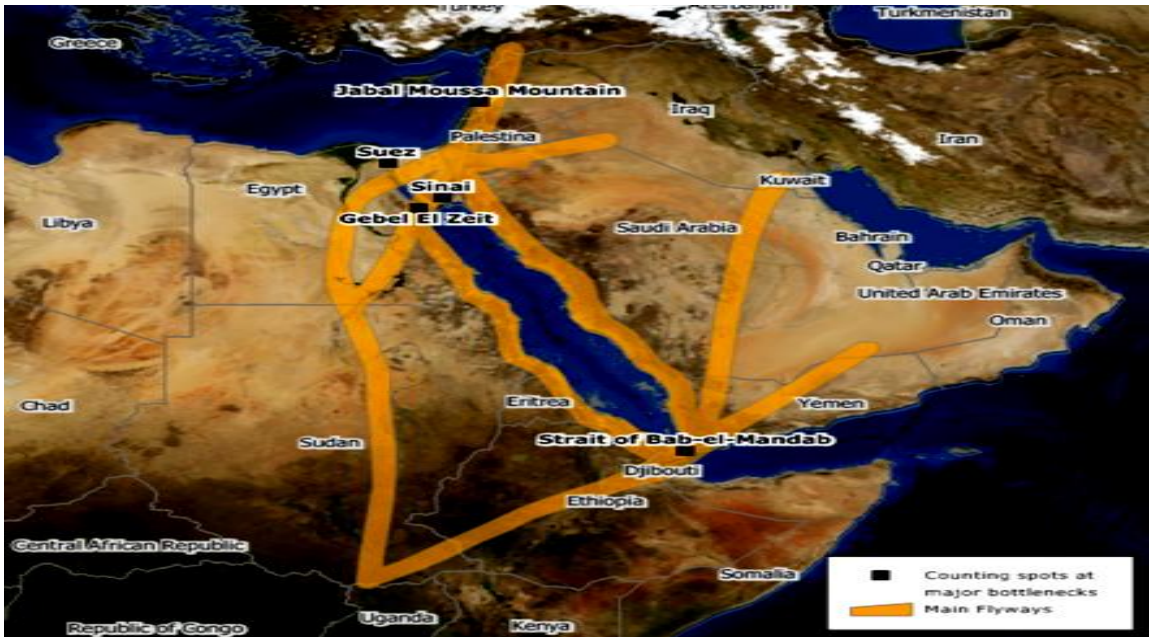
	safety data sheets as well as the following emergency equipment. Train staff in stock management and the proper handling of pesticides during transport.			
PPD	Any contamination of floors should be cleaned up immediately. Obsolete stocks should be centralized as far as possible, provided that container conditions are still safe for transport. The central store should meet the standard criteria	Yes	Measures that can be put in place to minimize dust and odour impacts of stockpiles including use of dust suppression sprays, fully enclosing stockpiles in sheds, covering stockpiles, using sheds with negative pressure systems and screening	
PPD (safe use of pesticides department)	All pesticide stocks should be inspected by the relevant national authorities and each product recorded and stock Pesticides in deteriorated containers should be repackaged and relabeled Stocks of doubtful quality or age should be sampled and	Yes	Materials with a potential to produce leachate and contaminated run off should be stored in a sealed and banded area to divert storm water away from the waste and contain and prevent impact from potentially	The environmental impacts are related mainly to handling, transport, and disposal operations. The major risk is related to dangerous toxic

	analyzed to determine whether pesticides can still be used.		contaminated run off. Covering these materials may also be required to reduce the potential for leaching generation, or to prevent or minimize gaseous or dust or other emissions	and hazardous waste materials

Migratory soaring birds:

Sudan is home to an estimated 653 species of birds (Avibase 2020), and it ranks third among African countries used as flyways by migratory birds. The migratory birds spending the winter in Sudan (October- March) and then returned to the breeding grounds on April. There are three routes, with two routes crossing the Gulf of Suez and passing down the Nile Valley and the west coast of the Red Sea (Egypt, Sudan, Eritrea, Ethiopia, and Djibouti), and the third route along the east coast of the Red Sea (Saudi Arabia, and Yemen) which crosses the southern end of the Red Sea at the Strait of Bab al-Mandeb to rejoin the other two before continuing south to the East African Rift Valley (Fig. 1).

Most of the bird migration across the Saharan Desert is known to take place on a broad front; the distribution of recoveries in Sudan shows concentrations (hotspots) along the Nile and at some other sites south of the desert. This is further supported from observations of distinct migration in Sudan, where many species have been observed migrating at the Red Sea Coast, along the Nile in the Khartoum area, and in the Darfur area in the west (Nikolaus 1987). The temporal pattern of



migration in the area shows a strong seasonal pattern with most autumn migration occurring during the period 20 August to 20 October and most spring migration during the period 10 March to 20 May (Hogg *et al*. 1984).

Fig. 1. A flyway is the whole area covered by a species or population of migratory birds over the course of the annual cycle, including breeding and non-breeding grounds and the connecting migration routes. **Source: http://migratorysoaringbirds.undp.birdlife.org/en/flyway#gsc.tab=0**).

Impact of agricultural chemicals on Migratory Soaring Birds:

The economy of the Sudan is highly dependent on agriculture, which takes an estimated 43% of its labor force (ILO estimates of2019) and accounts for about 30% of its GDP (World Bank, 2011).

Its crop portfolio is quite diversified, including cereals, oilseeds, industrial crops (cotton and sugarcane), fodder crops and horticultural crops (vegetables and fruits). Recently many of people rely on agriculture for income and employment. The increasing of agricultural intensification is occurring across the country in response to rising populations, causing significant increase in the cultivated areas. Also, the off-season production of vegetable crops was extended in large areas on Northern State due to climate change to solve the shortage during summer season (March to October). In recent years, several large private enterprises have emerged in River Nile and Northern States, producing fodder crops such as alfalfa and Rhodes grass for export, mainly to the Gulf countries and potato and wheat for local markets. These enterprises are usually highly mechanized; use efficient irrigation systems such as centre pivots and other forms of sprinkler irrigation (FAO 2020). These lead to intensive use of pesticides and fertilizers in the irrigated schemes and rain fed production all year around to manage the pests and increase the yield per hectare.

Farming practices impacts consist mainly of poisoning by pesticides (insecticides, rodenticides and avicides) and poisoning from infected livestock. Extensive and intensive use of pesticides occurs throughout the country and mortality from pesticide poisoning, through ingestion of prey or drinking contaminated water, may represent a significant threat to migratory birds along the flyway. Birds are extremely mobile, and it is therefore difficult to exclude them from areas that have been treated with pesticides. The impact of pesticides is probably greatest for storks, pelicans, cranes, harriers, and falcons, which frequently feed during stopovers (UNDP, 2013). In Sudan, according to a survey conducted by Sudanese Wildlife society and PPD, it was observed that the pesticides applied to control pests in agricultural schemes affected the migratory birds either directly of ingestion or contact of pesticides or indirectly as a result of ingestion of contaminated pests (unpublished).

Insecticides used for the control of horticultural and field crops:

Wheat crop is grown in Sudan in different locations particularly; Northern State, River Nile State and Gizera Scheme during winter season (November- March). Wheat seeds are treated with two neonicotinoid insecticides (imidacloprid and thiamethoxam) alone and with fungicide mixture (tebuconazole). The neonicotinoids are modern systemic and neurotoxic insecticides widely used as seed treatments. This kills the insect pest prey of vertebrates (e.g. birds) and affected birds

through the consumption of the treated seeds. Gibbons *et al*. (2014) reported that the fields sown with coated seeds, imidacloprid and clothianidin pose risks to small birds, and ingestion of even a few treated seeds could cause mortality or reproductive impairment to sensitive bird species. In Northern State after wheat is harvested most areas were sown with watermelon, tomato and onion as summer crops which considered as off season and need intensive use of insecticides (organophosphates, carbamates and pyrethroids). Moreover, along the Nile River banks huge horticultural production (vegetables and fruits) were cultivated with stallholders and misuse of pesticides was observed. This results in unnecessary contamination of water and environment and increasing risks to non-target organisms (e.g. birds).

In irrigated schemes, aerial application was adopted since the sixties of the last century the application of pesticides in cotton being under direct supervision of Plant Protection departments PPD. In 1979 the FAO/ARC IPM project introduced IPM in cotton, application is done based on regular survey of pest economic threshold level (ETL) (Dabrowski, *et al* 1998). There has been a positive policy shift to reduce pesticide application by discontinuing routine calendar spraying and linking application to field checks of pest infestation levels. This has reportedly resulted in a reduction of pesticide spraying on cotton from a previous average of 9-11spraysper season to an average of 2-3sprays. Other positive measures include the application of selective rather than broad-spectrum pesticides that can harm beneficial insects and lead to pest resistance. To reduce contamination from spillage, greater use is intended of closed mixing/loading systems, as well as GPS technology to limit the risk of aerial spray drift into sensitive areas such as irrigation canals. In these schemes the pest control operations in vegetable crops, are carried out by farmers using knapsack sprayers. This means that farmers had to be trained in pest control.

Recently the genetically modified (Bt) cotton was introduced, and the insecticides only applied to control the minor damage caused with thrips, aphids and whitefly in Gezira, Suki and Rahad schemes and rain fed areas. In these schemes, sesame crop was affected by the sesame gall midge, *Asphondylia sesame* and the sorghum crop is attack by the sorghum midge, *Contarinia sorghicola* and the fall armyworm, *Spodoptera frugiperda* which need spraying insecticides to reduce their damage.

The pest control options that restrict the use of insecticides are varied and may include diversifying and altering crop rotations, sowing dates, tillage, and irrigation; using less sensitive crop varieties in infested areas; applying biological control agents; and turning to alternative reduced risk

insecticides. These options are often most effective when applied in combination under an overall IPM strategy;

- Substitute (remove/replace) high risk chemicals.
- Following integrated pest management program utilizing all available methods in integrated manner to reduce the use of pesticides in various sectors.
- Similarly releases of other hazardous chemicals in the environment have to be managed and reduced to the minimum.
- Enforcement of laws and regulations as well as other guidance in area of chemical safety during handling and use.
- Awareness rising in the whole community addressing the hazards of chemicals and how the humans and environment can be protected.

A. Pests Control Operations

1. Quelea bird control in Sudan

In Sudan Quelea bird, *Quelea quelea aethiopica*, known by the common local names *"*Zarzur*"* or *"*Gudum Ahmer", is the major bird pest which can occur in huge flocks (breeding colonies may harbor 60 000 adults' ha−1) that are capable of devastating small-grain crops such as millet, sorghum, wheat, and rice inflicting serious damage and causing significant loss of these crops yearly**.** The total potential area of infestation is about 800000 square kilometers stretching from the Red Sea Hills in the east to the far western parts of the country (Kaske 1978). Migrations of *Quelea* follow a relatively simple North - South pattern like those of West African flocks and are dependent on seed availability.

This prolific bird pest has only one nesting season a year in Sudan (Bruggers *et al*. 1984). In August to October the birds migrate to favored savannah areas to form large breeding sites in forests, bushes, grasses, and weeds. In the dry season roosting concentrations occur near rivers, mainly the Blue and White Niles, Bahr El Ghazal and Sobat (Bruggers *et al*. 1984). During January to May huge flocks of the birds congregate in night roosts in suitable forests adjacent to water sources and not too far from feeding places (Kaske 1978). The breeding and roosting sites of quelea birds cover

12 states of Sudan, *i.e., El* -Gadarif, Kassala, Sinnar, Gezira, White and Blue Nile, Southern and West Kordofan and Southern, Eastern, Western and Middle of Darfur States as in (Fig. 2)

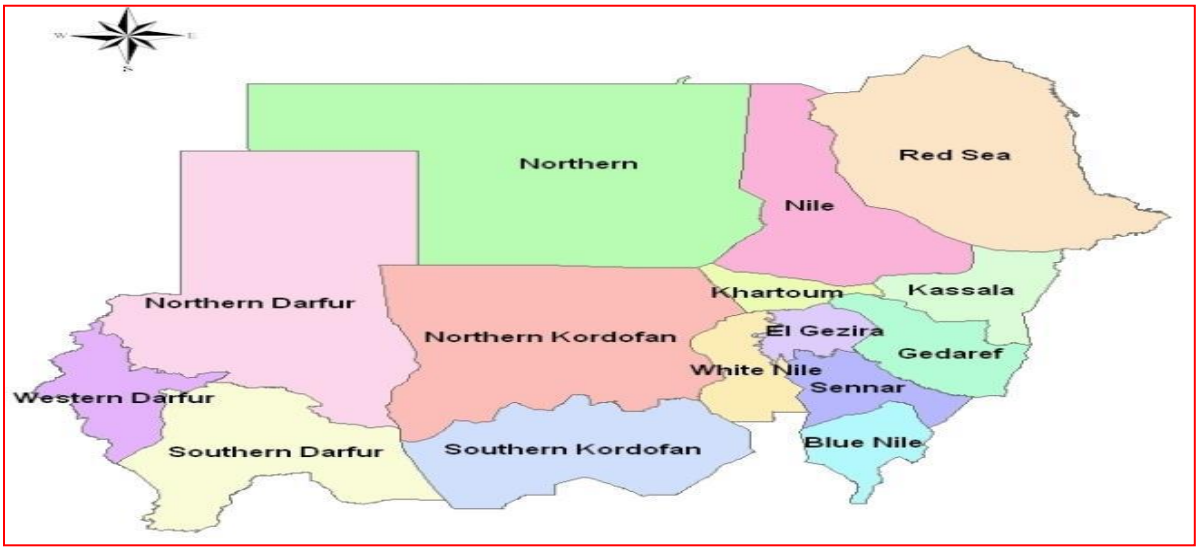


Fig. 2. The Breeding Sites of quelea in 12 States of Sudan (El Gadarif, Kassala, Gezira, Sinnar, Blue Nile, White Nile, Southern and Western of Kordofan and Southern, Western, Eastern and Middle of Darfur).

Method of Fenthion application:

The most common form of quelea control involves only aerial application of the avicides Fenthion (Table 4), the organophosphate Fenthion R 60% ULV (different commercial names), (Elliott and Allan 1989). Control operations start after the second week of September. The recommended dose of Fenthion for large scale applications is one litre per hectare. The sites are sprayed at range of 10 -15 minutes before sunset and an aircraft flying 2-3 m above the breeding colony at maximum speed of 150 km/hr. (Fatima & Saeed *2001*). This rate was successfully reported controlled the birds which lower than the dosage rates recommended by DLCO-EA usually used 2- 4 L/ ha and South Africa dosages ranging from 7 L/ ha up to as high as 14 L/ ha (Cheke, 2016).

Table 4: Avicides used for the control of Quelea bird *Quelea quelea aethiopica* **in Sudan**

Trade name of the product	Common name	Risk on MSBs
Fencal 600 ULV	Fenthion	Highly toxic. To avoid risk, poising quelea carcasses should be guarded or removed
Fenbest 600 ULV	Fenthion	
Thion 600 ULV	Fenthion	
Birdy 600 UL	Fenthion	

Source: PPD annual reports (2016)

Residual analysis:

After the treatment with Fenthion samples were collected and analyzed. A level of 0.5 and 0.1 ppm residues was detected in acacia samples treated with Fenthion which below the permissible level. According to this result, the use of Fenthion 600 ULV is environmentally safe in Sudan (Fatima *et al.* 2016).

Impact of quelea birds control on Migratory Soaring Birds

Predatory and scavenging birds can be contaminated by secondary poisoning when they eat quelea carcasses found up to20 km or more from the primary control site. Thiollay (1989) has recorded 80 species of predatory birds at breeding colonies in western and central Africa and 93 raptor species at risk are resident or seasonal migrants in sub-Saharan Africa (Keith and Bruggers 1998). To avoid the secondary poisoning where possible quelea carcasses should be removed from a site after spraying (McWilliam and Cheke, 2004).

Table 5: Recommendations to reduce the impact of quelea bird control on non-target species

Lead institution responsible to effect the changes	Requires change of practices	Requires legislative changes	Recommendations	Problem/Risk to birds or weak procedural areas

PPD	More research on environmental impacts of spraying with fenthion should be conducted	Yes	Develop or use alternative avicides that is more specific for quelea	Fenthion is very toxic to most bird species and insects
Research institutes and PPD	Sites that have many raptors or other predators (such as Marabou storks) should not be sprayed.	Yes	Aerial sprays should be avoided whenever possible. Development of the alternative technique to control Quelea by avicides	Primary and secondary poisoning, Pollution and non-target mortality
Research institutes. Training the PPD Staff to use GIS and remote-sensing to estimate the potential effect of quelea control	To avoid secondary poisoning, where possible Quelea carcasses should be removed from a site after spraying a and incinerated by control personnel wearing suitable protective clothing	Yes	Research is needed on methods that increase the efficiency of knock down (perhaps the addition of surfactants)	Possibilities of secondary poisoning especially in areas outside the sprayed sites.

2. Rat control in Sudan

Rat infestations are reported at significant levels when summer rains set in May with improved soil moisture and vegetation growth, stimulating rodent reproduction. During the prolonged dry spell of July, increased populations cause serious damage to crop during planting and

establishment by digging up the cultivated seeds extend to feed on newly sprouted seedlings. The poisonous baits with zinc phosphide and the anticoagulant are conducted by the Plant Protection Directorate. Timings of rat control efforts are especially important to get good control at a reasonable cost. Controlling rats before the sowing date of the crop brings substantial increase in yield (Hussain *et al*., 1991).

In Sudan Rat control campaigns are implemented either routinely after harvest or before sowing time as in the irrigated schemes due to reports indicating increased population above a threshold of 3rat/kilometer. Before baiting a plan of work is made the agricultural fields are divided into small areas to facilitate management and baiting. These units of work depend on type of farming. In the irrigated schemes the block is usually an acceptable working unit while in the rain fed mechanized schemes the unit may include about 100 farms. (Rat Control in the Agric. fields of Sudan – PPD report 2016). Usually, pre-baiting and post-baiting surveys are accomplished to evaluated success of the campaign. The main survey method used is "head light" method where the average rat number seen passing in front of a vehicle speed at about 40-50 kilometers per hour, on the main roads of cultivated field is taken as an index of rat population. Survey is mostly accomplished after sun set. (Rat Control in the Agri-fields of Sudan –PPD report 2016).

Rodenticides, used to control outbreaks of rats in agricultural areas, can be a particular problem to migratory birds if there are missuses of control, particularly anticoagulants either first generation anticoagulants (warfarin, Chlorophacinone,) or second generation anticoagulants (Bromadiolone and brodifacoum) or non-anticoagulants (zinc phosphide), when they eat either poisoned baits or poisoned prey (Table 2). Many raptor and scavenging species are especially at risk due to a regular diet of rodents, voles, and their carcasses. The application rate of poising baits is 10 -20 gm in active barrow. Missuses of application lead to the risk of exposure to birds.

Table 6: Rodenticides used for control of rates in Sudan and their risks of birds

Rodenticide	Primary risks *[1]	Secondary risks *[2]
Second-generation anticoagulants		
Brodifacoum	low to moderate	moderate
Bromadiolone	low to moderate	moderate

First-generation anticoagulants		
Warfarin	Low	Low
Chlorophacinone	Low	Low
Others (non-anticoagulants)		
Zinc phosphide	High	Low

Source: PPD annual reports (2016).

*1 & *2 To avoid risk, the remain of poising baits and rat carcasses should be removed.

Table 7: Recommendations to reduce the risk of Rodenticides

Lead institution responsible to effect the changes	**Requires change of practices**	**Requires legislative changes**	**Recommendations**	**Problem/Risk to birds or weak procedural areas**
PPD	The development of good agricultural practices (GAP)to prevent and manage rodent irruptions. Training of PPD staff and producers to use a GAP plan	Yes	Best practices to prevent/manage rodent irruptions. Rodent control operation should be taken up	Crops loss in the field, eat seeds and seedling

	and an effective IPM plan with regard to rodents		before sowing the seeds	
PPD, Rodent specialists	More studies focusing on the dose-response relations between bait concentration and mortality of various raptor species are necessary to understand incidents of secondary poisoning in raptors accurately	Yes	Restrict/ban 2nd generation anticoagulant rodenticides. Use less toxic, first-generation rodenticides which pose less risk to birds of prey Removal of bait after use and regularly search for rodent bodies so they can be disposed of safely	primary or secondary poisoning of non-target animals(Birds)
PPD, Rodent specialists	Flooding irrigation of the Cultivation. Trapping in small areas. Chemo-sterilization Survey and monitoring to collect data and possibilities to control the rodents early before sowing.		Where possible, consider using alternative methods of control to anticoagulant rodenticides, such as trapping	
Department of Safe use of pesticides	Ensure enough skill/capacity*(through training or use of simple manuals) to use rodenticides safely and effectively	No	Provision of professional advice (if necessary) on use of rodenticides.	

3. Desert Locust control:

Sudan is one of the key countries for desert locust (DL) breeding. Its vast winter breeding quarters stretch 147,200 km2 along the Red Sea, and the summer breeding habitat in central Sudan covers an area of 956,360 km2 (El-Tom, 1993). Thus, the DL Control Service is one of the most important services within the National Plant Protection Directorate (PPD) of Sudan. The Ministry of Agriculture allocates 26-39 % of the annual budget of the PPD for DL operation and 40% of all pesticides are used in DL control (Table 3). The PPD intensified its operations to control and prevent any escalation of the ongoing desert locust upsurge affecting the country.

The actual responsibility of crop protection rests basically with the Plant Protection Services (PPS) of the States. The federal Head Office in Khartoum, the PPD, coordinates the crop protection activities, provides pesticides, aircraft support, and equipment if necessary, and is responsible for migratory pest control, in particular locust control in the winter areas (December to January) breeding. The PPS report locust observations in their locality to the PPD in Khartoum. The capacities of the local PPS to conduct surveys and/or control operations by their own are limited. For that reason, the central PPD is often obliged to intervene also during the summer (July to October) breeding seasons to assist in the local governments to carry out their duties. Ground and aerial control operation are carried out against all stages of DL mature and immature swarms and different stages of Hopper bands. FAO is working closely with PPD and providing technical support in surveillance, monitoring and control operations.

The locust control department with quality control system for spraying operations is being set up to evaluate the efficacy of treatments, assessment of risks to environment and local people and staff and sampling of pesticide residues. Many pesticides belong to organophosphates and pyrethroids (Table 3) used in desert locust control present high risk to non-target organisms (such as birds) and to the human health, even if they are used judiciously. For these reasons research is needed for use in safer alternatives. Therefore, besides the conventional pesticides, at least two alternative control options to be used. The first option is the use of Insect Growth Regulator insecticides (IGR). IGRs are low-toxicity pesticides, which have low impact on non-target organisms and not harmful for mammals. IGRs insecticides are efficacious only against immature

locust stages – hoppers (nymphs), which make it impossible to use them against swarms of adults. The second alternative option is the use of biological control agents, in particular, the entomopathogenic fungi *Metarhizium acridum*, which cause epidemic diseases in locusts. Such biopesticides are highly specific as they kill only locusts and are harmless for humans, birds, and fish. Biopesticides fit very well into the preventive strategy.

Table 8: Locusticides Used for the Control of the locusts in Sudan and their risks of birds

Common name	Primary risks for birds	Secondary risks for birds
Fenitrothion	High	High
Diazinon	High	High
Propoxur	High	High
Diazinon	High	High
Chlopyrifos ethyl	High	High
Celtamethrin	Moderate to low	Low
Bendiocarb	High	High
Carbosulfan	High	High
Tralomethrin	Moderate to low	Moderate to low
Chlorpyriphos	High	High
Fluvalinate	Moderate to low	low
Pirimiphos-methyl	High	High
Fipronil	High	High
Cyphalothrin	Moderate to low	low
Malathion	Low	Low
Esfenvalerate+ Fenitrothion	Moderate to low	Moderate to low
Metarhizium acridum	No risk	No risk

Source: PPD annual reports (2016).

Table 9: Recommendations to reduce the risk of locust control on non-target

Lead institution responsible to effect the changes	Requires change of practices	Requires legislative changes	Recommendations	Problem/Risk to birds or weak procedural areas
PPD staff on desert locust management	Special care is taken to avoid using pesticides in ecologically and economically sensitive areas. Specialized team well trained to ensure that pesticides are applied when and where are absolutely necessary and to help improve the quality of the treatment. Extensive training programs for survey and control	No	Introduction of barrier treatment spraying only a small portion of infested area, thus saving money and environment.	The risk of aerial and ground sprays on non-target and environment
PPD staff	replace substances of high risk to birds with environmentally safe products. Adopt IPM	No	Use of malathion is (WHO class III) slightly hazardous rather than Fenitrothion this would greatly reduce risk to birds	Most of insecticides used for locust control are moderately hazardous
Desert locust Specialists	Field staff need to be awarded on exactly how to verify of the fungus	No	Use of biological pesticides, myco-pesticides based on the fungus *Metarhizium anisoplae* (var.acridum)	

4. Biological Control of Water hyacinth (WH):

The Water Hyacinth *Eichhornia crassipes* introduced to Sudan in the mid-fifties of the twentieth century, from 1955-1960 infested 3600 square km of White Nile and its tributaries. The Plants completely disrupted the biodiversity of the Nile and displaced all indigenous plants. Control of (WH) was first carried out by applying the herbicide (2-4, D). An environmentally sound and effective means of reducing or mitigating pests and pest effects is through the use of natural enemies. In 1979 the Sudan successfully used classical Biological Control to (WH) by introducing the two weevil insects; *Neochetina eichhorniae*, *Neochetina bruchi* and the moth *Sameodes albiguttalis.*

5. Integrated Pest Control of Fruit fly:

The Fruit flies distributed and covered (14) states, mainly the species *Bactrocera invadens* that introduced from Egypt in 2003 to Sudan. There was some other species *e.g. Ceratitis capitata, Bactrocera zonata , Ceratitis cosyra* (Walker). The applied method control carried out whole year by using Pheromone baits (Methyl Eganole + Malathion 57% EC) followed by Nutrition baits. The Seasonal treated area of fruits farms ranged from 6000 to 8500 hectare.

6. Integrated Pest Control of Green Pit Scale Insect:

The Green Pit Scale Insect *Plasmaspis phoenicis* introduced from Saudia Arabia to Sudan in 1976, infested 400 - 600 thousand Palm trees. The Integrated Pest Control Campaigns was carried out in Winter and Summer seasons through Cultural, Mechanical, Physical and chemical methods. In the chemical method using recommended dose of systemic pesticides (Confidor, Midas and Acoopird) in measured mixture solution and accomplished treatment by irrigated it in the barrow around the infested palm trees.

7. The Sorghum bug (Dura andat):

Sorghum bug (*Agonoscelis pubescens* (Thunberg), which belongs to the order Hemiptera (family: Pentatomidae), is a serious pest of sorghum which known locally as the “Dura Andat”, is one of the most serious pests of sorghum and millet grains in rain fed areas of Sudan (Schmutterer,1969). The insect inhabits mainly the flat central belt lying within isohyets range of 250-800 mm which was called central rain fed area in Sudan (Razig, 1978). This area includes south Kassala to Wad Elhileiw, the whole of Gadarif State, Rahad scheme and the adjacent Rahad basin, South Blue Nile (Sinnar-Damazin), west of the White Nile (Kosti to Elrrank ,Rahad basin to Elssimeih), the whole

of South Kordofan, eastern parts of west Kordofan and southern parts of South Darfur (Gaddura,1984).

Like other economically important Pentatomidae, the bug displays a remarkable annual life cycle characterized by short active period in the field(Aug-Nov) and long resting period on shelter trees, settle in dense clusters and remain hibernating from early November to early July (Schumutterer, 1969). The adults and sometimes the final nymphal instars generally feed on the crops when they are in the milky stage and cause atrophied grains (Whitefield, 1929; Bilal, 2003). Twenty or more bugs per head of sorghum crop may destroy all the grains so that the entire head becomes sterile. Heavy outbreak can therefore result in complete loss of the crop (Schumtterer,1969).

The treatments are carried out against hibernating insect populations on Acacia trees by ground spray of the recommended insecticides (the emulsifiable concentrates and Ultra low volume concentrates pesticides) (Table 4). However, every year the Plant Protection Directorate in Sudan spends millions to control the resting adult stage of this insect during the control campaign which starts in January and end in June. If a migratory bird is likely to be exposed, the toxicity of the pesticide is significant. The most common insecticides recommended for the control are organophosphates and carbamates (Table 4), makes any bird at risk of lethal or sub-lethal effects if they happen to be in the vicinity at the time of application, or shortly thereafter, or if they come into contact with exposed prey.

Table 10: Insecticides used for the control of Dura andat in Sudan

Common Name	Risk on MSBs
Bendiocarb 1% D	Moderate
Diazinon 60%EC.	High
Profenofos40%+Cypermethrin 4%W/W EC	Moderate
Malathion 57%	Low
Cypermethrin 0.25%DP	Low

Source: PPD annual reports (2016)

Pesticides must be registered with the Pesticides Committee and after consultation with the pesticides Committee, the Under-Secretary may make the regulations he may deem necessary for the implementation of the provisions of the Pesticides Act. He therefore makes regulations

concerning the degree of toxicity and risks of the pesticides, the distribution and use, storage and transportation etc. and may appoint competent persons to supervise the use and circulation of pesticides.

B. **Administration of spraying at agriculture schemes and its potential impacts on birds** .

Adopt proper pest control operations methods to be applied for avicides, rodenticides, Locusticides and insecticides terrestrially and aerially in harboring pest's sites; these should not be toxic to environment. But if the pests control is misapplied it can expose most bird's species to primary and secondary poisoning risks; to avoid the risks special care is taken to avoid using pesticides in ecologically and economically sensitive areas, and conduct extensive training programs for survey and control for PPD staff on pest management routinely with special care to save non-targeted birds through adopting integrated pest management at national level and for livelihood (farmers).

C. Strengths and Weakness in the operational procedures of PPD

The policy requirements to strengthen of PPD:

The Ministry of Agriculture should be strengthened and empowered through adequate legislations to implement animal and plant health protection practices. Strengthening these services should include:

1. Establishing an efficient epidemiology unit where data can be quickly processed.
2. Development of a networking mechanism involving relevant institutions, farmer's groups and NGOs for its health services. Such collaboration could facilitate information base on pests and diseases and operating as a national network for pest surveillance and detection.
3. Strengthen the role of extension services in plant protection and disseminate information widely on the use of pesticides and herbicides and their risks on non-targeted species including birds.

4. Adequate and appropriate training of staff with the required levels of competency and access to resources; good staff development and retention require secured sources of funding, including resources for dealing with operation emergencies and crises prioritization. Adequately funded and managed programmes are meaningful for stakeholder relations and awareness-creation.
5. Consistency of PPD goals and operations with government policy and legislation institutional stability (this should be properly considered and provided for well-defined public goals, direction on how to achieve them and a broad course of action to address control operation risks policy on disseminating information among stakeholders in support of transparency, and cooperation regarding operations requirements and regulations.
6. Collaborating with the Rotterdam Convention to strengthen capacity building programmes and the use of the knowledge base maintained by the Convention; supporting collaboration among different institutions to strengthen pesticide risk regulation; explore options to make regulatory risk data more transparent and accessible; strengthen research and education in alternatives to pesticides; - Stop all exports of crop protection products banned in the EU; only allow the export of severely restricted pesticides if these are regulated accordingly and used properly in the importing country; and support the re-evaluation of pesticide registrations in the country to be in line with FAO/WHO Code of Conduct

Suggested planned and regulations to strengthen the PPD to protect MSBs

1. Enforcement of laws and regulations as well as other guidance in area of chemical safety during handling, storage and method and time of application.
2. Setting national and strategic plan for continuous monitoring of hazardous chemical residues in various environmental compartments.
3. Development of awareness programmes in the whole community addressing the hazards of chemicals and how the humans and environment can be protected.
4. Building the capacities and capabilities of the PPD personnel concerned with chemicals management.
5. Hold annual or biannual technical training and workshops. These workshops facilitated by PPD staff together with experts who have strong plant regulatory frameworks — could

bring together national plant protection employees, border control staff and research/university scientists.

6. Following integrated pest management program, utilizing all available methods in integrated manner to reduce the use of pesticides in various sectors.
7. Changing farming techniques to use less chemical pesticides and opting for organic farming as opposed to the purely commercial option will increase the food options for the birds as well as provide more regions for habitat creation.
8. It is necessary to implement (4) campaigns of survey programs into two seasons carried out by PPD after and during each National Pest Control Campaigns *(Quelea, locusts, Rodent, Dura Andat, Fruit fly, Green scale insect of palm trees and Weeds*) to ascertain the effect of pesticides on the non-target birds.

Opportunities

Activate and implement the pesticides and pest control products Act of1994 and bylaws to monitor and follow up the import, registration, deportation, storage, commercial handling, proper application and inspection of pesticides to ensure the safety of the environment in general, workers and animals with especial careful to beneficial birds and MSPs.

In the proposal of the Plant Protection Law for the year 2022 that is being prepared, a definition of Migratory Soaring Birds (MSPs) will be introduced in addition to the inclusion of two articles that offer best opportunities in biodiversity protection including MSBs by protecting them from the risk of exposure to pesticides and also offer PPD strengthening to provide proper pest control services without negative impact on environment.

Recommendations on expired stockpile of agrochemicals.

Stockpile management plan can be required as a condition of authorization to demonstrate how stockpiles are being managed, with the aim of preventing unauthorized stockpiling of materials and preventing or minimizing environmental harms. The recommendations to manage and prevent the stockpile is detailed follows:

- Make development of a stockpile management plan a condition of authorization (for importation).
- Measures that can be put in place to minimize dust and odor impacts of stockpiles including use of dust suppression sprays, fully enclosing stockpiles in sheds, covering stockpiles, using sheds with negative pressure systems and screening.
- Materials with a potential to produce leachate and contaminated runoff should be stored in a sealed and banded area to divert storm water away from the waste and contain and prevent impact from potentially contaminated run off.

Covering these materials may also be required to reduce the potential for leaching generation, or to prevent or minimize gaseous or dust or other emissions.

Agro-chemicals used in private and agriculture government schemes

The majority of the imported chemicals are used in the agricultural sector specially the irrigated schemes in central Sudan and in private schemes. Cotton (47% of annual import) is the major crop receiving most frequent spray followed by, vegetables (26%), sugarcane (15%), in comparison to National pests (Plant Protection Directorate (PPD), 7%) and public health sector (2%). Spraying of cotton, sugarcane, and wheat (especially in irrigated schemes) is under the direct control of Crop Protection Sections (CPS) of the Irrigated Schemes & Sugarcane Corporations. However minimum governmental supervision is given to spray operations in vegetable crops, which received an increased importance in recent years. Pesticides used are highly toxic to bird's exposure by different means such as direct ingestion of pesticide granules and treated seeds, treated crops, direct exposure to sprays, contaminated water, or feeding on contaminated prey, and baits, these cause birds mortality or indirect effects through food chain as which can affect bird population.

Agro-chemical authorization procedures adopted by PPD in Sudan.

In Sudan pesticides are managed and governed by Pesticides and Pest Control Products Act 1994 which replaced the Pesticides Act of 1974. The act regulates all activities related to pesticides registration, importation, storage, transportation, use, formulation and any other related activities in the country through the National Pesticides Council (NPC). The registrar of the council is the

Director General, Plant Protection Directorate (PPD). The 1994 Act is a general umbrella law with various explanations and specific details, which may require periodical revisions, dealt with in seven relevant bylaws, which are easy to amend on periodical terms, as necessary. The last revision of these list of bylaws was done in 2002. **Pesticide's regulations in the Sudan** was governed by the Pesticide Act / 1974 which was amended to Pesticide and Pest Control Act / 1994. The Act regulates all activities related to pesticides import, transport, storage, uses, formulation, and any other related activities in the country. These functions are executed by the National Pesticides Council (NPC). The NPC is a multidisciplinary inter-ministerial committee, which includes representatives of all stakeholders within the country including the Ministries of Agriculture, Animal Resources, Health, Research Institutions, Universities … etc. The council is chaired by the Under Secretary of the Ministry of Agriculture with the Director General of the Plant Protection Directorate (PPD) as the repertoire and Registrar of the Council. The Registrar is responsible for all administrative and executive functions of the Council. According to this act subsidiary council can be formed in all states of the Sudan. Similarly, subsidiary central or regional, permanent, or interim committees are formed to assist in performing specific functions mandated by the council. The 1994 Act is a broad general umbrella law with various explanations and specific details, which may require periodical revisions, dealt with in seven relevant bylaws, which are easy to amend on periodical terms, as necessary. The last revision of these bylaws was done in 2002. A list of (7) bylaws is given below:

1. Trading and organization of the commercial handling of pesticides and pest control products bylaw for the year 2002.
2. Pesticides and pest control products inspection bylaw for the year2002.
3. Organization of the storage and transport of pesticides and pest control products bylaw for the year 2002.
4. Protection of personnel dealing with pesticides and pest control products bylaw for the year 2002.
5. Importation of pesticides and pest control products bylaw for the year 2002.
6. Registration of pesticides and pest control products bylaw for the year 2002.
7. Formulation of pesticides and pest control products bylaw for the year 2002.

Pesticide's registration in the Sudan can be summarized in the following points:

1. Applicants must first fill Form 1 for provisional registration and submit it to the registrar of the NPC which ensure the environmental sustainability through integrated pest management and other eco-friendly means and environmental protection and conservation of natural resources.
2. The NPC passes the form to the technical committee which reviews the information given in the form according to the Pesticide and Pest Control Act/1994 and either recommends to the NPC to reject or accept the provisional registration of the pesticide.
3. Products approved for provisional registration shall be tested by relevant research institutions under local conditions and results of the test shall be approved by the National Pests and Diseases Committee (NPDC) which either recommends (or rejects) to the NPC the registration of the product for commercial use according to the following measures:
    a) Method of testing should follow the approved protocol.
    b) Residues of the product(s) tested in edible crops and/or the environment should be within acceptable limits (Codex Alimentarius).
    c) Standard treatment(s) must be included in every field assay and the standard should be an already registered product.
4. Test products are only recommended if their biological performance is as good as or better than that of the standard products.
5. The NPC reviews the recommendation of the NPDC and either is approved its or rejects. If the product is approved, it is thus registered and introduced for commercial use.

Recommendations for stronger control of agrochemicals

- Several of the insecticides of high risk to birds, such as carbofuran, diazinon, chlorpyrifos and endosulfan of high risk to birds must be removed from the market and incentivize alternatives; introduce mandatory evaluation mechanisms for existing and new products or restricted in the country.
- Neonicotinoid insecticides have become a main replacement for the organophosphates and carbamates. Further research is needed to investigate the

risks from neonicotinoids and other approved insecticides which may pose a similar hazard.

- Substitute (remove and replace) insecticides with a high risk to birds with safe alternatives, and inclusion of criteria in the Rotterdam Convention to reduce risks of imports toxic to birds, promotion of Integrated Pest Management, and identification of areas of significant risk of poisoning of migratory birds.

It is necessary to coordinate with the Irrigated schemes, Sugar Factories establishments, Associations of farmers and producers by developed monitoring means and continuous awareness and training programmes to take care of avoiding the use of a harmful pesticides during migration season of (MSBs) and other beneficial non- target birds.

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