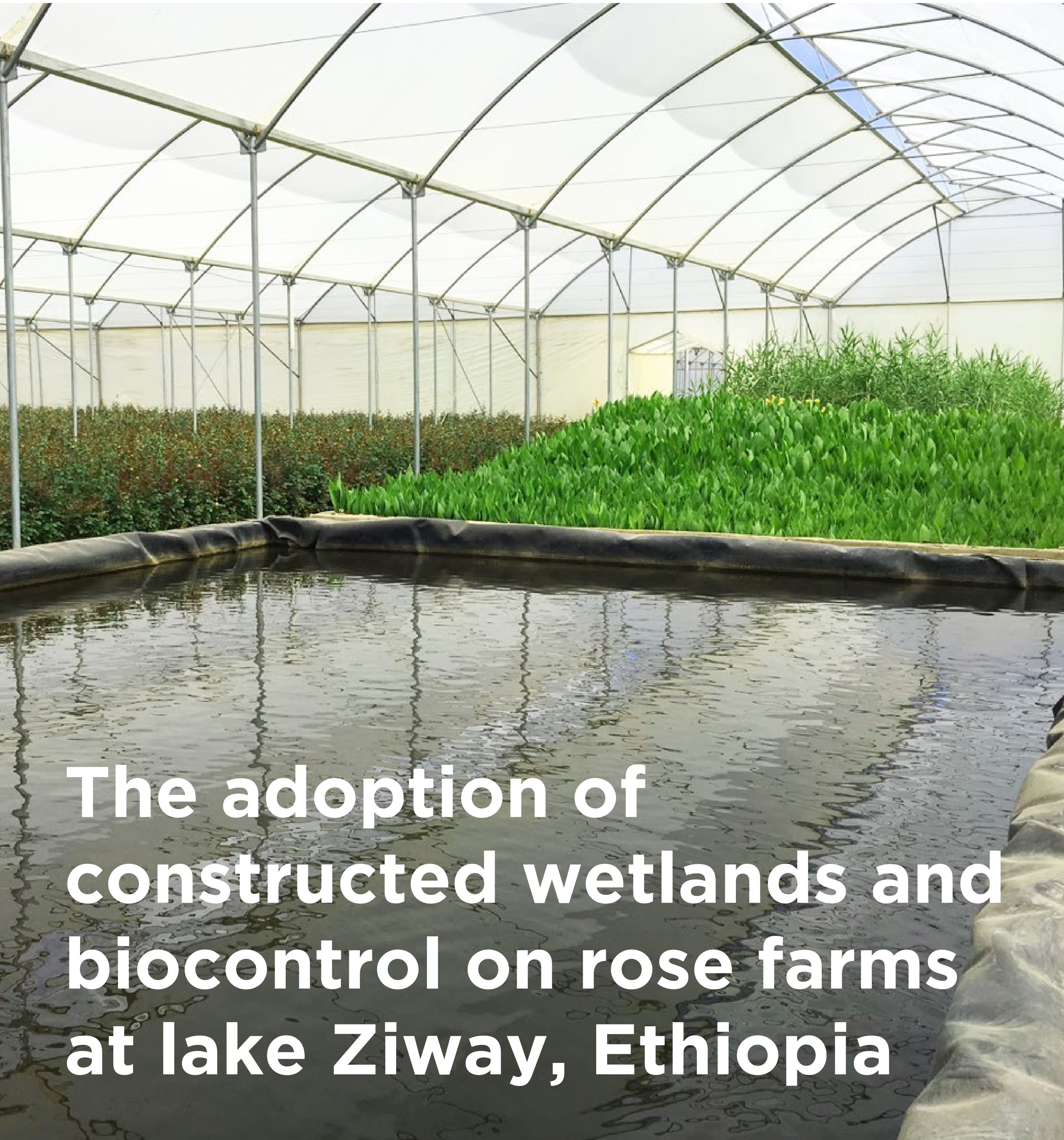


The adoption of constructed wetlands and biocontrol on rose farms at lake Ziway, Ethiopia

Insight report

2020

Contents

Executive Summary

This report reviews the output and impact of five related projects partially supported by IDH, which were aimed to enhance the sustainability of the production cut roses around Lake Ziway, Ethiopia. The projects focused on two aspects – constructed wetlands to eliminate or reduce potential pollution of the lake and the use Integrated Pest Management, based on the introduction of biological control (biocontrol) agents to replace the use of synthetic chemical pesticides and therefore reduce risks to workers and the environment. Partners in the projects are Afriflora/Sher, ECOFYT, Koppert, Floriculture Sustainability Initiative and the Ethiopia Horticulture Producers Export Association.

The system of constructed wetlands, described in the report, was shown to reduce the total amount of pesticides in waste water from the farm by up to 99.98%. This allowed the recycling of the waste water back into the farm, resulting (at Afriflora/Sher Farms) in a saving of 500 m3 per hectare per year. The purity of the water allows the fish to be sustained and is better than published figures for Lake Ziway itself.

The introduction of biocontrol agents for control of Red Spider Mite and Mealy Bug has been successful and resulted in reduced application of synthetic chemical pesticides (estimated at 80% reduction in insecticide use). At present, there are no biocontrol agents for control of Thrips and Aphids that have proven to be effective under Ethiopian conditions and these pests still need to be controlled by judicious use of pesticides. When the use synthetic chemical pesticides is needed, products of low toxicity (to human and environment) are the products of choice.

Sher Farms has assisted in the training of personnel on other farms in the region and these have also adopted both wetlands and IPM.

It is concluded that the use of wetlands and IPM is a cost effective way of significantly reducing the risk to workers and the environment from synthetic chemical pesticides. Further support should be considered to a) further promote the use of wetlands and b) facilitate the development and uptake of current and new biocontrol options.

Acknowledgements

The author would like to thank the management and staff at Afriflora/Sher, both in the Netherlands and Ethiopia, as well as Ecofyt and Koppert experts, all of whom provided the background and information for this report.

Acronyms

Biocontrol	Biological pest control
CSOS	Civil Society Organisations
EHPEA	Ethiopian Horticulture Produce Export Association
GAP	Good Agricultural Practices
IPM	Integrated Pest Management
l/ha	litres per hectare
l/m2	Litres per square metre
MPS	A private organisation that started as a project from Bloemenveiling hall Westland that develops and manages certification for sustainable production of flowers, plants, vegetables and fruits

Methodology

In order to determine the impact and outcomes of the introduction of constructed wetlands and biological control of pests in flower production in at Lake Ziway in Ethiopia that has been undertaken by Afliflora/ Sher Ethiopia and its partners, Koppert and ECOFYT, supported by IDH, a pesticide expert was contracted. The expert reviewed available project documents, including the agreed project proposals, summarised below, and available reports. Literature review was also undertaken to determine the current status of flower production in the region and its impacts, as well as, the latest developments in wetland use for treatment of pesticide contaminated water and the implementation of biological control. Discussions were held with staff of all partners. A visit was made to Sher Ethiopia rose farms at Lake Ziway to review the wetlands and biocontrol systems implemented and discuss issues and outcomes with Sher Ethiopia personnel. Two other flower farms that are members of EHPEA were also visited to see how both wetlands and biocontrol are being adopted in the sector and to determine any constraints they may face.

Business Case Study

Context

Flower production in Ethiopia is a rapidly growing sector, providing local income and improved livelihoods, as well as production of good quality produce for export – thereby contributing to the regional and national economy. The industry began in 2004 following a push from the Ethiopian Government for foreign investment. Since then there has been a rapid growth in the industry. Export earnings from flowers was around US$65 million in 2006/2007 and had risen to US$261 million by 2016, around 80% of horticulture and 10% of total export earnings, with roses accounting for 80% of this amount. There are now over 100 flower farms in the country, covering more than 1,700 ha and producing more than 2.1 billion flower stems. Roses are the most frequently grown flower, with 60 companies concentrating on this crop.

However, there is a need – and growing public demand - to produce flowers sustainably, with minimum impact on the environment and without harming human health or the community. The series of projects described below shows how this can be achieved through positive actions with regard pesticide and water use.

Both IDH and Afriflora recognise the need to control pests during production to avoid unacceptable damage and loss of the crop. This, however, needs to be achieved while minimizing or eliminating any risk to human health and the environment. Conventionally, pest management has relied on the use of synthetic chemical pesticides, which can result in unacceptable risks to the user, high levels of pesticide residue on the plant and discharge of contaminated water into the environment, in particular Lake Ziway, if not handled and used properly. The goal is to reduce this risk, through:

- Removal of pesticides from waste water (which also means that the water can be recycled through the farm)
- Replacement of chemical pesticides, where possible, for the majority of pest management interventions

ECOFYT and Koppert provide the technical expertise to address these.

Solution

Two separate, but complimentary project themes were established to address the issues:

- Establishment of wetlands to filter water exiting the greenhouses
- Introduction of biocontrol as part of an IPM strategy to optimise pest management and reduce reliance on synthetic chemical pesticides

Partners

AFRI FLORA Sher Ethiopia | ***Afriflora Sher***

Afriflora was founded in 2005 and through Afriflora Sher in Ethiopia possesses the largest rose farm in the world. The farm is located at 3 sites: Koka, near lake Koka, Ziway and Adami Tulu, near Lake Ziway in the Oromia Region, Ethiopia. Between them, the farms have a total working surface area of around 525 ha, comprising of processing halls, which are connect to 38 greenhouses. The farm employs approximately 12,000 workers cultivating, harvesting and packing the roses. All are exported to Europe.
Since its foundation Afriflora`s goal has been to grow and sell roses that have been sustainably cultivated, respecting both people and the environment. They are a world leader on implementing novel solutions to sustainable flower production. To this end Afriflora has been leading the way to sustainability in the sector, with programs addressing:

- The environment
- Worker safety and rights
- Community support (including education and health)

Afriflora Sher continues to strive to enhance, adopt and promote sustainable practices into the future. As a result of these efforts, the company has certification from all relevant initiatives for retailer delivery:

- MPS - Socially Qualified
- MPS - GAP (Good Agricultural Practices)
- EHPEA Code of Practice for Sustainable Flower Production

- GlobalG.A.P.
- Ethical Trading Initiative
- Fairtrade
- Afriflora Sher is also ISO certified.

ECOFYT

ECOFYT is Afriflora Sher's partner in the wastewater treatment developments. It is a Dutch company with over 25 years of experience with designing and building constructed wetlands for (waste) water treatment. From the first plans for pilot systems in 2011, to the present day, ECOFYT is involved also in supervising the maintenance of the now 67 constructed wetlands, scattered over SHER`s greenhouses.

Koppert

Koppert was founded in 1967 and has developed itself into a worldwide market player in the biocontrol. With almost 1800 employees and offices all around the world Koppert has become the household name in the biocontrol. Koppert and Sher have been working together for already 8 years. They have the same values and goals and together they have developed, and continue to develop, a strong biocontrol system in Ethiopia.

IDH

IDH, the sustainable trade initiative, convenes companies, CSOS, governments and others in public-private partnerships. Through these partnerships, IDH aims to develop approaches and promote sustainability from niche to norm in mainstream markets, delivering impact on Sustainable Development Goals. The focus of activities is on creating positive impact on deforestation, living incomes and living wages, working conditions, environmental toxic loading and gender.

Flowers and Plants is one of the six focus sectors of IDH's Fresh & Ingredients program, which provides cross-sector solutions on working conditions, agrochemical use and climate change issues. This recognises the rapid expansion of the floriculture sector in recent years, leading to significant economic growth in production countries, but at the same time, the sector is faced by a number of sustainability challenges, which the program was established to help address.

The program focuses on five issues:

- Working conditions (living wage, women workers, health and safety)
- Agrochemical use
- Water use
- Water contamination
- CO_2 emissions (transport)

Floriculture Sustainability Initiative (FSI)

IDH supported the establishment of the Floriculture Sustainability Initiative (FSI), a global, multi-stakeholder platform, that unites over 50 global key players. FSI is a market-driven initiative that brings the international floriculture supply-chain together to improve sustainability practices through field projects and increased transparency. FSI members are fully committed to their shared ambition of 90% flowers and plants from responsible sources by 2020.

The Ethiopian Horticulture Producers and Exporters Association (EHPEA)

EHPEA supports Ethiopian flower farmers and exporters and contributes to the national economic development in Ethiopia through more responsible production methods. It represents and advocates the interests of the Ethiopian horticulture production (particularly farmers) as part of creating a profitable and sustainable sector by helping to address the main concerns such as reduction of environmental impacts, water demand and resource competition, and achieving more sustainable production in line with the international market requirements.

Projects

Wetlands

The first attempts to use constructed wetlands macrophytes for pesticide removal were carried out as early as the 1970s, but only in the last decade have constructed wetlands for pesticide mitigation become widespread. To manage any risk from pesticides in waste water, Sher Ethiopia proposed that wetlands be established to treat waste water exiting their greenhouse facilities. A Wetland is essentially a reed bed through which the water flows. The reed-bed system decontaminates the water through a process of filtration and microbial breakdown (metabolism). A joint project was agreed in 2012 between Sher Ethiopia, the Dutch government, HoAREC and ECOFYT to do this. Following construction and set-up of a pilot wetland that treated water from two greenhouses (`lines`), IDH partnered with Afriflora Sher to test the water exiting the system for pesticide residues. Demonstration of the effectiveness confirmed that the water exiting the system was of sufficient quality to recycle and re-use the water in the greenhouses. The IDH project ran from September 2014 to December 2015.

Following the successful demonstration of the Wetlands, a further project was agreed with EHPEA, of which Afriflora Sher is a member, and IDH to share results and promote and construct Wetlands in 15 farms around Lake Ziway and elsewhere in Ethiopia, that are members of the association. Afriflora Sher provided demonstration and capacity building for the EHPEA member farms. The project also aimed to develop 20 local experts on wetland technology knowledge. Initially, project ran for 24 months from 1st January 2017 to 31st December 2018, but was extended to June 2019.

The overall aim of both projects was to reduce environmental risks from discharge of untreated waste water and through recycling/reuse of water, bring benefit to farms in terms of water saving and reducing water competition with the local community.

Biocontrol

The project goal was to convince key Ethiopian exporting producers of flowers and vegetables of the economic benefit of a holistic IPM system by lowering their total cost per unit produced, plus significantly reducing the amount of chemical pesticides used during production (and hence reducing residues).

Afriflora Sher, Koppert and IDH partnered, initially, in a year-long project in 2015 and subsequently in a two-year project from 1st January 2017 to 31st December 2018 to increase the percentage of the Sher Ethiopia farm under biocontrol initially to 60%, rising to 80% by the end of 2018. An addendum to this project was agreed to extend to December 2019

Hypothesis

The projects were aimed at confirming:

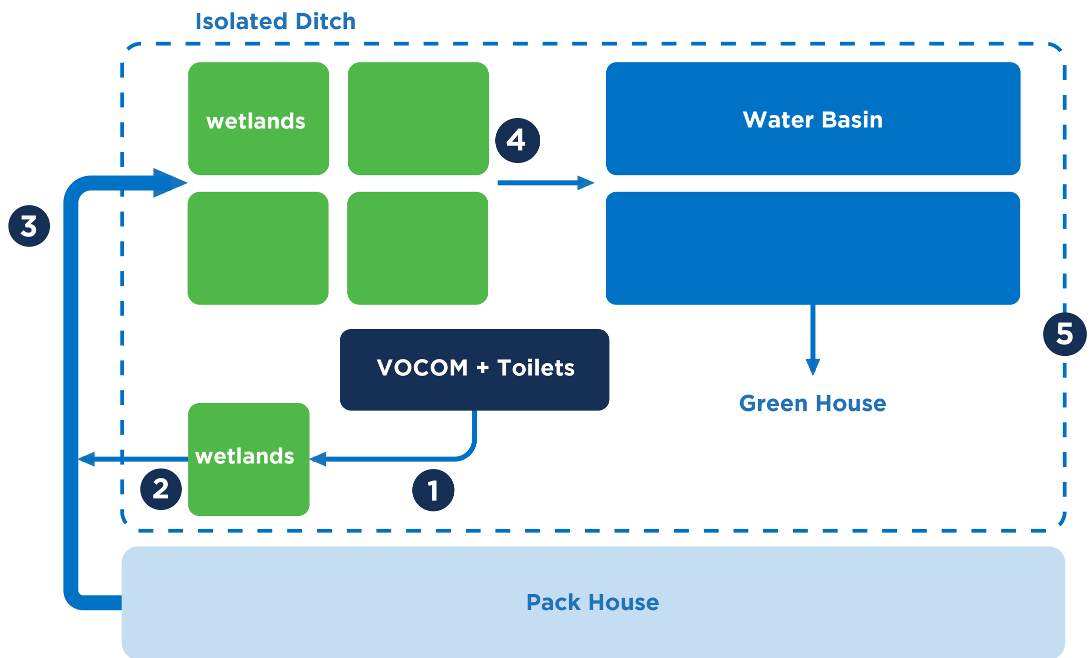
- Wetlands remove pesticide residues to an extent that waste water can be recycled into the farm
- Biocontrol is an effective tool within an IPM strategy that results in reduced use of synthetic chemical pesticides
- Farms within EHPEA recognise the benefits of wetland and biocontrol and are willing and able to adopt the approaches

Findings: Wetlands

Technical characteristics

The wetlands, described by Hoarec (2013), are sand filled basins, isolated from the underlying soil through thick, Polyethylene liners and planted with (locally found) marsh plants (or macrophytes) such as reed, Napier grass, cattails (bull rushes) and canna lilies. The waste water is collected in sumps and, through pumps, dispersed over the wetlands' surfaces. While seeping through the sand bed, the water undergoes different processes, from filtration (through the fine sand particles) to chemical reactions (e.g. with oxygen, generated by the roots of the macrophytes) to biological processes (e.g. by bacteria that feed on or decompose the polluting elements of the wastewater). After treatment the water is collected in basins and then pumped back to the centre of the greenhouse where it is reused. In this way all waste water is recycled, with the exception of the massive tropical rain events, that happen from time to time. Since this would lead to overloading and erosion of some of the wetlands, it is directed to bypass the most of system (filtration through the first wetland would still occur – see below), but by definition any pollutant contained would be very highly diluted. Drought has no impact on the wetlands: the final design locates them inside the greenhouses and since the production continues 365 days per year, wastewater will always be 'available' to irrigate the wetlands.

Figure 1: Final Design Layout of Wetlands (numbers refer to the positions where water samples were taken)



Water with potentially high contamination from the facility where pesticides and fertilisers are mixed and distributed (the Vocom), plus toilets, are treated by a single wetland and then passes to a ditch which contains water with a much lower level of contamination from the packhouse. Water from this ditch is then treated by another (set of) wetlands before exiting to water basins and from there to a storage ditch, before being pumped back into the greenhouse facility for re-use. One series of wetlands serves to treat water from three greenhouses.

In initial designs water flowed horizontally across the wetlands and the second set of wetlands were placed outside the greenhouse. However, the horizontal wetlands are more prone to clogging-up with sludge (requiring the surface to be removed), so in later designs the water flows vertically through the wetland, which is less likely to clog. Also, the second series of wetlands were brought inside the greenhouse to avoid drying out or flooding. This final design has an effective life of an estimated 10-20 years with minimum maintenance before renovation is required.

Sher Ethiopia, with supervisory and monitoring advice from ECOFYT, have now constructed a total of 67 wetlands with capacity to treat all water from the greenhouses at the Ziway and Adami sites (total working area of 525 ha) that are able to process a total of 550m3 of water a day (350 at Ziway farm and 200 from Adami Tulu farm). The pilot wetlands were established in 2011 in greenhouses at Ziway and their efficiency over time was determined by comparing exiting water from the wetlands constructed in 2014.

Residues in water

There have been several tests on both the untreated water (influent) and the treated water (effluent) by accredited water laboratories in Ethiopia and the Netherlands. The latter with a multisampler that can detect almost 600 residues. The combined weight of residues detected (given in micrograms per litre) in samples were taken at various points along the system

1. Water from the Vocom prior to entering the wetland
2. Water exiting the first wetland
3. Water in the ditch between greenhouses prior to entering the second series of wetlands
4. Water exiting the second series of wetlands
5. Water in the ditch from greenhouses with no wetlands

The positions of the above samples are shown on the standardised diagram of the wetland set-up.

The majority of residues tested for were never found in influent (water from Lake Ziway) nor in the outflow from the Vocom. Although the actual amount of pollutant varies, a reduction of around 99.9% results from passage through the system, see figure 2.

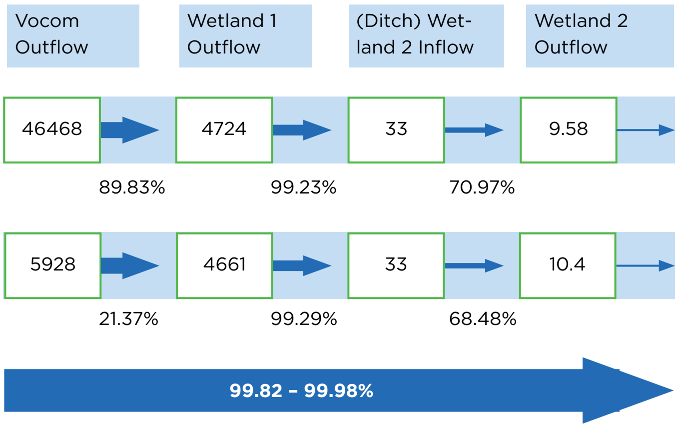


Figure 2: Total weight (micrograms per litre) of residues in samples taken at different points in the wetland system. Percentages show the amount removed at the preceding stage. The lower arrow shows the percentage removed by the system as a whole.

It can be concluded that the wetlands are effective in removing residues from water even when the level of contamination is relatively high. With regard to individual active ingredients, removal rates go up to 99.9%. With a few compounds the efficiency of removal is low, this should be a factor and driver for pesticide choice. It can also be noted that the sample taken from the ditch between greenhouses (collection point 3) has a much lower amount of pollutants than the sample taken from the outflows from the Vocom and the first wetland (collection points 1 & 2). This is because of the dilution effect of the water from the packhouses, which also runs through the ditch. The sample taken from the second wetland inflow prior to entering the second series of wetlands (collection point 3) has 30% less pollutants on average and following passage through the second wetland (collection point 4), 79% less pollutants on average.

Table 1: 3 Randomly Selected Wetlands

	N° of Pesticides	microgr./litre
Wetland outflow 28	12	13.85
Wetland outflow 35	13	8.26
Wetland outflow 39	14	12.19
Mean	13	11.43

- *Wetlands constructed in 2014 prove effective over several years with minimum maintenance*
- *Number of residues found are lower than when wetlands first constructed due to improved practices*
- *100% recycling of water for rose cultivation, no pollution, no waste*

Water quality in the holding reservoirs contain breeding Tilapia tested fit for human consumption!

Samples taken from the outflow of the second set of wetlands (collection point 4) of three wetland `lines` in October 2019 showed the presence of a total of 16 different residues with a mean total of 11.43 micrograms per litre (range 8.26 – 13.85). The highest reading for an individual active ingredient was 8.2 micrograms per litre, with the majority of active ingredients detected being less than 1 microgram per litre.

At this point, water quality is good enough to sustain fish populations and the holding reservoirs contain breeding Tilapia. The level of contamination in harvested fish has been tested and found to be fit for human consumption (see picture)

It can thus be concluded that the wetlands were effectively removing a high percentage of pesticides from the water, even though some remained. The efficiency was in-line with published literature, which indicates that some pesticide classes are more effectively removed than others: insecticides > fungicides > herbicides. According to their chemical constitution, they follow the order of pyrethroid > organophosphorus > triazole > amide > triazine > ureas (Vyzmazal and Brezinova, 2015). However, the net result is that the water exiting the wetlands contains considerably lower levels of pesticide contamination than the water entering the wetland system. The number of residues found exiting the system are also lower than compared to the first constructed wetlands due to improved practices in both construction and pesticide applications.

Concluding, testing confirmed that the water exiting the wetlands can safely be recycled for use on the farm and thus no discharges to the lake are made (only during high rainfall events to prevent overflowing, some water that may contain very highly diluted contaminants will be discharged from the storage ditch into the lake).

Further, results confirm that different lines show a similar efficiency in removal of residues. As the lines were constructed in 2014, their effectiveness is maintained over time. The efficiency of removal of individual active ingredients could be one of the factors in the choice of pesticides when chemical control is needed.

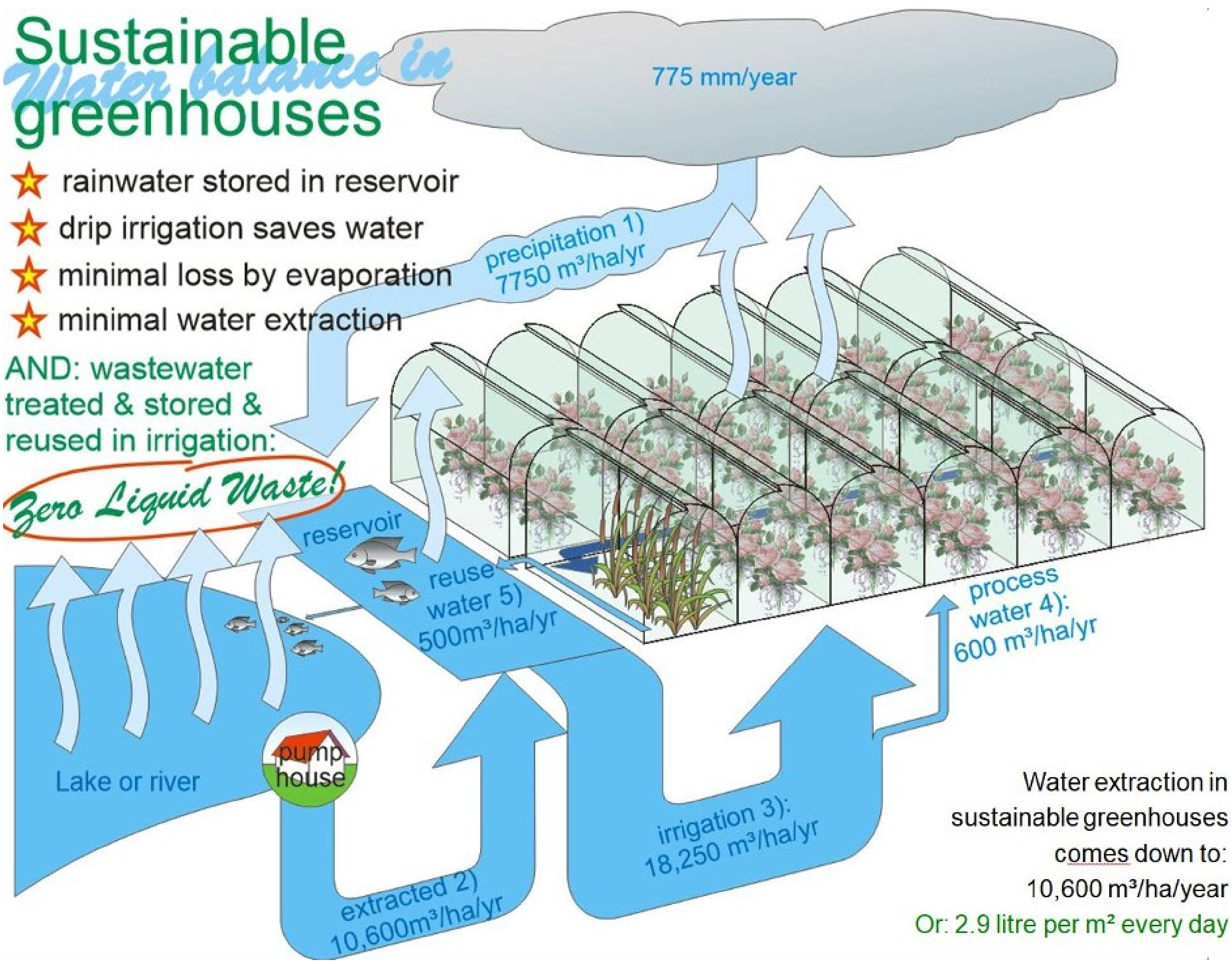
Certificate of fish testing

Water Use

Irrigation of the crop is optimised by the use of drip irrigation, which has been estimated generally to reduce water usage in greenhouses by 30-50% (O`Conner and Mehta, 2016). At the Sher farms, water exiting from the wetland system is pure enough to recycle and re-use on the farm. In the `Sustainable Greenhouse' system used by Sher Farms, water from the wetlands exits to the holding ditch, which also receives collected rainwater and water extracted from the lake and is returned to storage tanks in the greenhouses for use. The recycling of water along with use of rain water results in significant reductions in water extraction from Lake Ziway, estimated as 42% or the equivalent of 2.1l/m2 lower than traditional greenhouses(5.0l/m2 in `traditional greenhouses` dropping to 2.9 l/m2 with sustainable greenhouses), equating to 11,025 m3 per day over the entire (525 ha) farm or 7,665 m3/ha/yr. This is illustrated in Figure 3.

It is worth noting that the `value` of water in terms of crop production is considerably higher for roses compared to other irrigated crops grown in the region: Jansen et al (2007) estimate that the value of irrigated water (net income received by farmers per unit of irrigated water) as 17 – 29.5 Birr/m3 for roses compared to, for example, 0.6 – 3.8 Birr/m3 for tomatoes.

Figure 3: Water use by Sher Ethiopia farms



Training

ECOFYT has trained a local employee to oversee and maintain the wetlands. Experts from EHPEA have also been trained as planned. Sher Ethiopia has encouraged visits to their farms to view the wetlands and explain their construction and functioning.

Costs

As the construction of wetlands at the Afriflora Sher sites was an iterative design process, the cost is not indicative of what local construction of a standard design would be. This is further confounded by the fact that some wetlands were retrofitted into functioning greenhouses, whereas others were built when the greenhouses were constructed. It is more appropriate to use figures for construction at EHPEA member farms. This is given below.

With regard maintenance, a single trained engineer checks the pumps for the wetlands once a week (including taking reading to enable calculation of water throughput). The wetland themselves require minimum maintenance – the shift from horizontal flow to vertical flow wetlands resulted in less silting and clogging of the wetland surface (which would require remedy by removing the surface layer). The wetland vegetation is cut back twice per year. The costs are not considered significant.

Motivation

Motivation for construction of wetlands is the increasing societal pressure to avoid release of contaminated waste water into the Ziway lake. Additional benefit comes from the re-use of water, which further reduces the amount of water extracted from the lake.

Barriers

All Sher Ethiopia`s greenhouses are now served by Wetlands. The only barrier in the future sustainable use is continued access to expertise and facilities to check on their efficiency. A further barrier is that some pesticides are not effectively removed by the wetland system, this can be solved through use of other products that are effectively removed, and/or replacing their use with biocontrol.

Findings: Biocontrol

Technical characteristics

Pest attack threatens both the yield and quality of roses. Control of pests (arthropods – insects and mites - diseases and weeds) is therefore a necessary management activity. Chemical pesticides have been the mainstay of pest control but provide a risk to human health and the environment – both occupational through contamination of workers and through release of contaminated water into the environment (in particular Lake Ziway). Adoption of IPM, which includes the use of alternatives to chemical pesticides, such as biological control (biocontrol)agents, as well as the judicious use of chemical pesticides, when necessary, is one way of reducing risks.

What is a Biocontrol agent?

Biocontrol agents include:

- Predators of insect and mite pests, usually also insects or mites that eat eggs, larvae and/or adults of the pests
- Insect parasites (parasitoids) that parasitize and kill eggs, larvae and adult insect pests
- Microbes (mainly bacteria, fungi or viruses) that infect and kill insect pests, nematodes or weeds, or kill or act as antagonists against disease organisms
- Nematodes that infect and kill larvae and adults of insect pests
- Pheromones that affect the behaviour of insect pests
- Botanical pesticides that are obtained through extraction of natural chemicals from plants

Biocontrol agents used

Biocontrol used on Sher Farms

Sher has adopted an IPM approach and as part of this has aggressively pursued the use of biocontrol. Biocontrol is mainly targeted at arthropod pests (insects and mites). The main pests found in the greenhouses are:

- Two-spotted Spider Mite (Tetranychus urticae)
- Western Flower Thrip (Frankliniella occidentalis)
- Citrus Mealybug (Planococcus citri)

The main disease problem the fungus Podosphaera pannosa which causes powdery mildew. This is currently controlled through weekly application of chemical fungicides. Application of pesticides is made by small spray teams using a central piping system from the Vocom (where the pesticide is mixed) that supplies hose application equipment. The spray team wears recommended Personal Protective Equipment and signs are posted in the spray areas to exclude workers entering during spraying and for the recommended re-entry period.

The biocontrol agents being used are predatory arthropod species that eat the eggs, larvae or adult pest species, additionally insect pathogenic fungi are being tested, which grow through the cuticle of the insect pest to infect and kill it, as well as, entomopathogenic nematodes which infect and kill moth larvae (caterpillars). There use is summarised in the table below.

Table 2: Bioagents tested at Sher/Afriflora

Pest	Beneficial	Application Rate	Frequency of Application	Comments
Two-spotted Red Spider Mite	Predator Mite – *Phytoseiulus persimilis*	Depends on infestation level High: 10-20 mites/m2	Weekly	Fast acting predator – applied first
	Predator Mite – *Neoseiulus californicus*	Medium: 5/m2 Low: 3/m2	Weekly	Longer term impact – applied second
Western Flower Thrips	Predator Mite – *Amblyseius swirskii*	Presence detected by Blue Sticky traps. Application rate as above	Weekly	Failed to effective establish and provide adequate control
Citrus Mealybug	Predatory Beetles – *Cryptolaemus montrouzieri*	High infestation 10 beetles/m2 Average 5 beetles/m2	Applied when pest observed, 3 applications, 5 days apart	Just applied around area where pest seen
	Entomopathogenic Fugus - *Lenanicilli-um muscarium*		Experimental	Replacing Predatory Beetles
Aphids	Entomopatho-genic fungus		Experimental	Inadequate control

Within an IPM strategy pest control interventions (chemical or biological) are normally made according to the number of pests observed in the crop. All greenhouses are monitored by Scout Teams who scout the greenhouses from Monday to Wednesday. Trained scouts are paid a premium over other workers on the farm. The Scouts place paper markers on plants where pests are observed. Biocontrol agents are applied on Thursday, Friday and Saturday. Both species of predatory Mite are applied around the pest markers and also at random along each row of roses (random applications are still made if no mites have been found on the row). For Mealybug application of predatory beetles are made at the time of scouting, applications being made at and around plants where pests has been found. Control of both pests was said to be good, resulting in at least a 60% reduction in spray applications at outset and now reaching 80% reduction (stated as 80% biological control) for Mites.

Possible moth infestation are monitored using pheromone traps (which attract adult male moths); moth numbers are low and any caterpillars seen by the Scout Teams are collected by hand. Exceptionally spot spraying of chemical insecticides may be used. Thrips are monitored with blue sticky traps (the color attracts the thrips along with some other flying insects).

Use of predatory Mites to control thrips was not successful. This was said to be due to generally low pest levels, which resulted in the predatory mites not getting established. However, large influxes of thrips occur when the Teff crop is harvested. Thus, thrips are currently being controlled using chemical pesticide – although more selective products, with less impacts on beneficials (as well as being less hazardous) are now used.

It was stated that Mealybug had only become a pest since the adoption of biocontrol for Mites, presumably as the pesticides previously used for their control also controlled Mealybug.

Overall supervision of the Biological Control program is by Koppert experts (one expat and one local), although final decisions of pest management actions (release of biological control agents) is by the farm management based on recommendations from the Koppert team. Full records of pest numbers of biocontrol releases are kept by the Koppert team and shared with Sher management. Experimental trials on new biological control agents are carried out by Koppert.

Monitoring for Pests

Dispensing Predatory Beetles

Since the introduction of biological control, aphids are becoming more common. Although the use of entomopathogenic fungi has been tested for control, this has not been successful to date, so chemical pesticides are used when needed. However, it was stated that there has been more naturally occurring beneficial insects, such as ladybirds (ladybugs), have been observed since biological control was introduced. This raises the possibility that secondary pests such as aphids may be controlled by these natural enemies in the future.

Additional to biological control of arthropod pests, the fungus Trichoderma ssp. (in addition to chemical fertiliser) is applied in propagation lines and areas where plant growth is poor. This agent provides control of root rot diseases (including Pythium, Rhizoctonia, and Fusarium) and enhances growth.

All biological control agents need to be imported, either from Koppert in the Netherlands (predatory beetles and mites) or from Dudutech in Kenya. Shipments of live agents are made twice a week (by plane). For each shipment customs clearance (import documents under phytosanitary regulations) are needed. The system is complicated. Individual farms obtain a licence to import individual products, once they have this they can import the defined biological control agent. Each shipment still requires individual documentation for customs clearance, including one from a bank confirming payment has been made. The licenced farm can also import agents that can be used on other farms.

The crop is hand weeded.

Training Schemes

Koppert has trained the scouts and the on-site IPM/Biocontrol expert. Each scout team consists of one supervisor and up to 12 scouts. The Supervisor goes through a month of training. The Supervisor provides weekly training to the scout team, which ensures that issues like levels of pest infestation are given appropriate focus.

Costs

It is estimated that the annual cost of the Biocontrol Program is one Euro/m2.

Motivation

Adoption of biocontrol is a response to increasing public and therefore, buyer and retailer, demand to protect workers and consumers, as well as the environment, from possible contamination with chemical pesticides. The replacement of chemical pesticides is the most effective way of achieving this. Additionally, the quality of roses – most notably stem length – was said to be greater with the introduction of biocontrol, which results in higher prices for the product. However, replacement of chemicals with biocontrol agents is not always possible. Where chemicals are used their responsible use within an IPM system also minimises risks. This includes using less toxic chemicals, as well as applicators wearing recommended Personal Protective Equipment, adherence to re-entry periods (the time between application and when workers can re-enter the crop) etc.

Barriers

The main barrier is the lack of an effective regulatory framework for importation and local production, which means that there is always a chance that biocontrol agents will become unavailable. Another constraint to further expansion of biocontrol is the resources available to test new potential biocontrol organisms and under a range of conditions – effectiveness of biocontrol agents is influenced by ambient condition (temparature, wind etc.), even in the more controlled environment of a greenhouse. Understanding how application rates and timings might have to be adjusted according to conditions is needed. Finally, availability of local IPM experts is a potential constraint, which needs to be addressed as IPM and biocontrol is adopted more widely.

EHPEA

Wetlands

On the basis of the positive results at Afriflora Sher the use of wetlands was promoted to membership of EHPEA. The IDH project initially targeted 15 farms. By 2019, 30 farms have wetlands (six of these preceded the IDH project). The construction of these wetlands has been overseen by EPHEA`s Waste Management Department, with the wetland design being undertaken by consultants based in Kenya. Training for farm employees was also carried out by EHPEA.

Two farms were visited Florensis Abyssinia Farm PLC, which grow a range of flowers for export and ET Highland Flora, which grows roses. In both cases the current wetlands have been recently installed (3 – 6 months ago), although ET Highland Flora had a small wetland for over seven years, which they have now upgraded. Both used Kenyan consultants for the design. With this design the decontaminated water exits to a landscaped storage pond (see picture). As the wetlands are new no measurement of pesticide levels have been made. This is planned by EHPEA using a local private laboratory for the analysis. Water from wetlands is being recycled.

External Wetland at Florensis

EPHEA put the cost of locally constructing a wetland system at between 400,000 and 2.1 million Birr (Euro 12,250 – 64,250), depending on the difficulty of construction (topography/geology) and wetland size.

Biocontrol

Both farms visited are using biocontrol. Florensis stated that 90% of the pest management required was by biological control (predatory mites for thrips and fungus for whitefly) resulting in an 80% reduction in pesticide use. ET Highland Flora used to use 100% biological control, but recent problems with aphids, whitefly and thrips has resulted in a return to using chemical control.

Both farms cited a lack of research as a constraint to using biological control (EPHEA has supported some research). The lack of a registration system for production and use of biological control agents was also highlighted as a constraint.

Conclusions

Wetlands

The introduction of wetlands is a highly effective means of reducing pesticide contamination of water exiting the green-houses, although the efficiency is dependent on the pesticide type. The effectiveness and need are recognised by the farm owners, who have been willing to invest in construction and maintenance – the former being up to Euro 65,000, while the latter would appear to be fairly low. Additional to this is an `opportunity cost` for wetlands that are constructed within the greenhouses. This is lost flower production on the area occupied by the wetlands. If the final design is used throughout the Sher`s greenhouses i.e. all wetlands were within the greenhouses (in the initial design the second set of wetlands were placed outside the greenhouse), this would amount to an area of 0.6 ha. However, this is partly offset by the longer projected lifespan of the wetlands within the greenhouses. Placing all wetlands within the greenhouses means they are unaffected by rainfall, which means they do not dry out and would not be inundated during heavy rain. This investment underlines the commitment of Sher to protecting the environment through the use of Wetlands. The fact that other farms have also adopted wetlands demonstrates that their benefits are also recognised by other farm owners. When asked why they had invested in the wetlands, farm owners said that reduced environmental footprint of their farms was the driving force. The Ethiopian Government recognises that wetlands are an effective option for reducing water pollution from intensive commercial agricultural production and, while it is not a legal requirement, the Government encourages farms to construct them. Farm managers recognise that reduction of their farm`s environmental footprint is not only expected by government, but increasingly by their customers and the public at large – and thus is important to maintain their `licence to operate.`

The efficiency of pesticide removal depends on the pesticide molecule involved, which is in-line with the published literature. Overall, the total reduction in the pesticide load of water exiting the wetland system is over 99.9% and the water is of a quality that allows recycling back for use in the greenhouses saving approximately 500m3 of water per hectare.

Biocontrol

Further risk reduction in agrochemical use is achieved through adoption of IPM, including replacing some chemical pesticide applications with biological control agents. This approach has been considered for some years (den Belder and Elings, 2007, den Belder et al., 2009), but Sher Ethiopia and other EHPEA member farms has successfully operationalised this. Not all pests can be effectively controlled using biological control agents, so there is still a need to use some chemical pesticides, however, applications are made based on scouting and there has been a move toward using more selective and less toxic products. This, along with an 80% reduction in the use of chemical sprays (80% biological control) means that risks of worker contamination, pesticide residues on flowers and environmental contamination are considerably reduced. It should be noted that although maximum pesticide residue levels (MRL) are not legally set for roses (they are only set for food crops), the issue of pesticide levels on flowers is gaining attention with regard working conditions in the greenhouses and also florists in Europe (Toumi et al, 2016). Pesticide use (amount, toxicity classification and handling) is closely monitored as the farms are MPS-GAP certified.

Farm owners recognise that the initial investment in the use of biologicals is higher than using chemical pest management. However, they claim that higher production occurs in the longer term through the use of biological pest control. Furthermore, there is the possibility of opening up new (low chemical residue) markets. The recurrent cost of one euro/m2 is within the range of chemical control costs for protected crops.

A recognised constraint to biological control is that there is no standardised registration system for biological control agents in Ethiopia. This means that each shipment requires documentation for use on individual farms. As well as over bureaucratic, it also means that importing new biological agents for testing against pests that currently still require chemical control is constrained. Adoption of regulations for biological control agents by the Ethiopian authorities would not only benefit growers, but also workers and the environment as it will speed up the adoption of biological control and reduction in the use of chemical pesticides. Elings et al (2018) report that the main predatory mite currently used naturally occurs in the region, along with other beneficial species. They see no ecological threat from importation of the biological agents currently used.

Overall Impacts and Business Case

Overall the adoption of wetlands and biocontrol results in a significant reduction in contamination of water used on the farm and reduced risk to workers and the environment. It further facilitates more efficient use of water through recycling. This is clearly shown by the data available. The water leaving the wetland system is, in fact, less contaminated that water in the lake itself. This is clearly demonstrated by comparing the residue levels in samples taken from the wetland system to those reported by Teklu et al (2018) for samples taken from Lake Ziway between 2009 and 2014. For example, the amount of Spiroxamine (a commonly used fungicide) in lake samples ranges from 6.9 – 57 micrograms per litre, whereas none was detected in water leaving the wetland system. The authors also speculate that the reduction of pesticide residues in the lake in recent years stems from the adoption of wetlands. However, further sampling of water passing through the latest wetland design at Sher, and the wetlands being used on other farms, would help to further promote the approach to all farms in the region and beyond. IDH should consider supporting this. It should be noted that local testing facilities for water quality is limited and the ease and cost of regular sampling and testing would be improved by the establishment of more public or private certified laboratories.

With respect to further promotion of effective biocontrol options. IDH should consider supporting the testing of new biological control agents (e.g. for control of aphids and thrips), their integration with remaining chemical control options and capacity building for establishing a robust and effective registration system for biological control agents (which could include local production of agents that is successfully done in Kenya, but not possible under current laws in Ethiopia) is something that IDH could consider supporting. This support would result in reduction in costs of adopting the two strategies of wetlands and biological control – the former through adoption on a large-scale with resulting economy and the latter by reducing the cost of supplying biological control agents. It is clear that reducing impacts of pest management for flower production is increasingly a requirement along the value chain and is an important element in the future `licence to operate` of the growers.

As stated above the business case for adoption of these practices rests with a continued `licence to operate.` This is based on:

- Minimising the risk to workers from agrochemical use through IPM adoption, largely based on biocontrol
- Elimination of discharge of contaminated water into the environment through adoption of wetlands
- Minimising pesticide residues on crop and cut stems
- Reduced water extraction from Lake Ziway through adoption of sustainable practices (collection of rainwater) and recycling of water from the wetlands

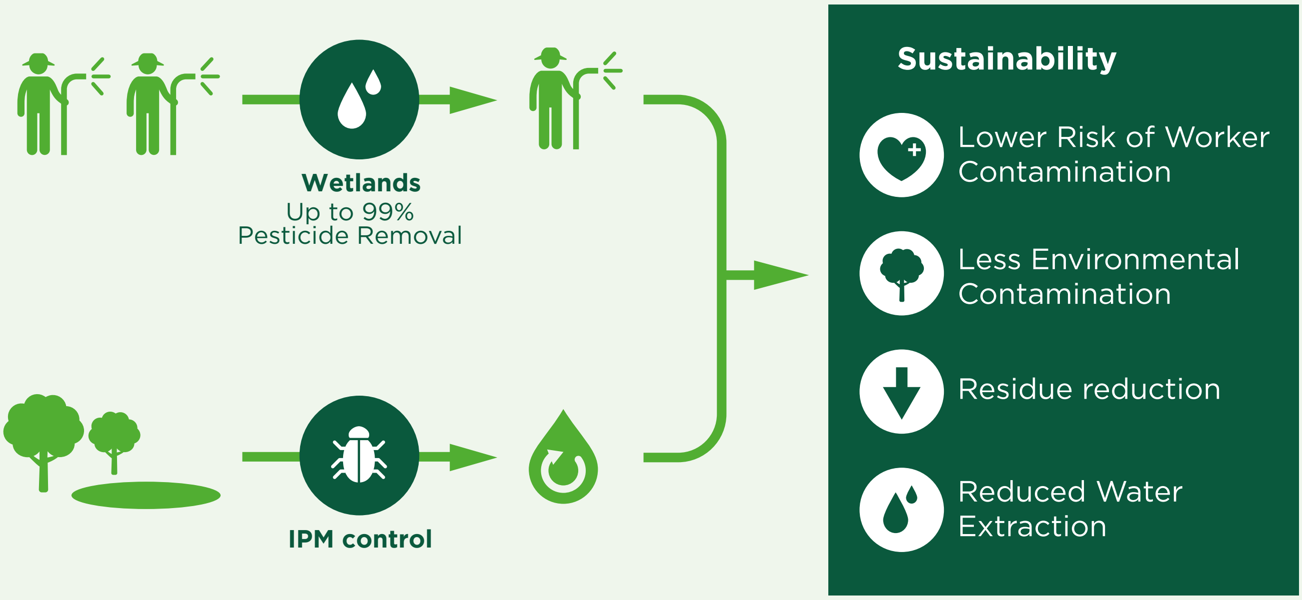
Buyers, retailers and the Ethiopian Government continue to expect these issues to be addressed.

The continued sustainable production of roses and other flowers around Lake Ziway benefits the local population as the farms provide a significant source for employment in the region and also the nation as roses provide a large proportion of export earnings. The net return per unit of water used is much higher for roses compared to other irrigated crops, meaning that rose production provides a water efficient option for export crops. Changing to other export crops is thus likely to exacerbate conflicts over scarce water resources.

To further encourage and facilitate uptake of wetlands and biocontrol, the Government needs to ensure the correct institutional and regulatory frameworks are in place – technical facilities for testing wetlands and an appropriate registration system for importing and testing biocontrol agents, and local production where appropriate. IDH`s role has been pivotal to the further adoption of wetlands and biocontrol; further support would help to spread this further to become standard practice throughout the industry.

In summary the adoption of IPM and wetlands have the following benefits:

- High efficiency of wetlands when combined with biocontrol within an IPM strategy
- Significant reduction in contamination of water used on the farm
- No pollution of rivers and lakes
- Less water intake and more efficient use of water through 100% recycling
- Safer working environment and reduced risk to workers
- Scouting allows for lower, more targeted pest control applications
- Crop health is less dependent on human interventions
- Pro-actively meeting future marketing requirements



Recommendations

To further promote use of wetlands and biocontrol across the flower sector, and broader in the horticulture sector, in Ethiopia the following is recommended:

For farmers

- Adopt the two strategies of wetlands and biological control simultaneously
- Further testing of residue levels and new trials for biocontrol agents

For government institutions

- Provide a regulatory framework promoting IPM and water stewardship
- Invest in capacity building and education in IPM and water stewardship
- Invest in accredited laboratories for water and residue testing

For sector organisations

- Promote IPM and wetland simultaneously to achieve better results and lower costs
- Provide capacity building of regulatory authorities in biocontrol and water stewardship
- Support the testing and integration of new biologicals (including local production)
- Strengthen in-country expertise
- Adopt good practice for IPM and water stewardship in relevant code(s) of practice
- Highlight and promote the business case and benefits for adoption of IPM and water stewardship

References

den Belder, E. and Elings, A. (2007) A Research and Development plan for the introduction of Integrated Pest Management in the Ethiopian Rose Sector. Plant Research International B.V., Wageningen, The Netherlands

den Belder, E., Elings, A., Yilma, Y., Dawd, M. and Lemessa F. (2009) On-farm evaluation of integrated pest management of red spider mite in cut roses in Ethiopia. Final Report to the Ministry of Agriculture and Rural Development. Wageningen UR Greenhouse Horticulture, Report 296. WUR, The Netherlands.

Elings, A, Messelink, G., Kruidhof, M., Leman, A., Cuesta Arenas, Y. and van der Wurff, A. (2018) Integrated Pest Management Component of the Ethio-Dutch Program for Horticulture Development Contribution of Wageningen University and Research – Final Report (Report WPR-711), WUR, The Netherlands.

Hoarec (2013) Briefing on the potential of constructed wetlands for sustainable horticulture development in Ethiopia. Horn of Africa Environment Centre and Network, Addis Ababa University.

Jansen, H., Hengshijk, H., Legesse, D., Ayenew, T., Hellegers, P. and Spliethoff, P. (2007) Land and Water Resources Assessment in the Ethiopian Central Rift Valley. Alterra-rapport 1587. Alterra, Wageningen, The Netherlands.

O`Conner, N. and Mehta, K. (2016) Modes of Greenhouse Water Savings Procedia Engineering, 159 259-266.

Toumi, K., Vleminck, C., van Loco, J. and Schiffers, B. (2016) Pesticide Residues on Three Cut Flower Species and Potential Exposure of Florists in Belgium International Journal of Environmental Research and Public Health, 13, 943-956.

Teklu, B., Hailu, A., Wiegant, D., Scholten, B. and Van den Brink, P. (2018) Impacts of nutrients and pesticides from small- and large-scale agriculture on the water quality of Lake Ziway, Ethiopia Environmental Science and Pollution Research International, 25(14): 13207–13216.

Vymazal, J. and Brezinova, T. (2015). The use of constructed wetlands for removal of pesticides from agricultural runoff and drainage Environmental International 75, 11 – 20.

FSI 2020

SherEthiopia

AFRI FLORA

idh the sustainable trade initiative