Darwin Initiative
Final Report

*To be completed with reference to the Reporting Guidance Notes for Project Leaders (http://darwin.defra.gov.uk/resources/) it is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin project information

Project Reference	20-018
Project Title	Pesticide Impacts on Biodiversity in Ethiopia & Agroecological Solutions
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Partner Institution(s)	PAN Ethiopia; Addis Ababa University; Institute for Sustainable Development, Ethiopian Wildlife and Natural History Society, Ethiopian Institute of Biodiversity
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Project Leader Name	Keith Tyrell
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1 Project Rationale

The project was implemented in two areas of Ethiopia's Rift Valley, close to the towns of Ziway (on Lake Ziway) and Arba Minch (Lake Chamo, opposite the Nechisar National Park which is also one of the Endemic Bird Areas of the World as identified by BirdLife International).

Diversity and abundance of Rift Valley migratory birds, and particularly wetland species, are declining. National experts implicated excessive pesticide use in nearby flower, cotton and vegetable farming, aerial spraying of *quelea* birds (deemed a pest to local agriculture) and effluent from caustic soda and pesticide formulation factories (where POPs are still produced, amongst others). Data on pesticide volumes entering aquatic systems is lacking, leading to National Parks and the Ethiopian Wildlife & Natural History Society prioritising ecotoxicological assessment of contamination and bird declines. However, they lack capacity to conduct monitoring adequate to establish a link.

National policies on food security and agricultural exports have increased reliance on agrochemicals, but without adequate measures to avoid side-effects on human and environmental health. Farmers and policymakers are unaware of the economic costs from pesticide harm (e.g. disruption to pollinators and biological pest control); few Rift Valley stakeholders understand how agro-ecological farming methods which conserve biodiversity can reduce poverty by improving farm income and supporting ecosystem services; local communities remain unheard in conservation and agricultural policy forums; many cotton smallholders are in debt as poor yields fail to cover their high chemically driven production costs; and an ecosystem approach to tackling these related issues and highlighting potential ways forward (e.g. TEEB approaches) is weak.

Addressing these problems by building capacity for the Ecosystem Approach, ecotoxicological monitoring and understanding ecosystem services and how they relate to biodiversity will help Ethiopia deliver its NBSAP, implementing CBD Articles 7 (monitoring activities impacting on biodiversity) and 13 (promoting biodiversity) and PoW on Agricultural Biodiversity.

2 Project Achievements

The project adopted a revised logical framework in Year 2 which is reported against throughout this report unless otherwise stated.

2.1 Outcome

Outcome:	Improved capacity of Ethiopian farming communities, government agencies and other stakeholders to (a) identify and understand the harmful environmental effects of agrochemical use close to biodiversity-rich wetlands (b) develop and implement practical solutions based on agroecological farming and (c) align agricultural policies with biodiversity conservation goals. Farming communities around the Rift Valley Lakes will benefit from safer and sustainable pest management, better water quality and ecosystem services. Government agencies and conservation bodies will gain the skills to monitor pesticide impacts jointly with rural communities and feed robust evidence into policy forums		
	Baseline	Change by 2016	Source of evidence
Indicator 0.1 *Desk officer and official support assigned by Arba Minch Plant Health Clinic to support project on biodiversity monitoring by year 2*.	No desk officer or support.	The Plant Health Clinic hosted the local project office since the end of Year 1, and assigned two officers to the project Local Monitoring Team. In year 3, the Zone Agriculture office conducted an evaluation of PAN E programme in Arba Minch in support of a new joint programme to further support agroecological cotton production in the area. The Agriculture office was happy with the results/progresses made by the farmers and dedicated farmer training centres (FTCs) in eight villages to use them train farmers for the 2016/2017 production season. The Zone cooperative department assigned an officer to help the established	Annex 2.1. Arba Minch final report (

		cooperative in marketing aspects.	
Indicator 0.2 *Species richness in cotton cropping areas under IPM management increases by 50% compared to conventional plots by year 3.*	No known data	Statistically significant differences demonstrated for a large cotton farm, with natural enemy counts under both IPM and food spray higher than conventional management using pesticide sprays. Similar results were observed in the second commercial farm and in smallholder plots but could not be statistically confirmed.	Annex 2.1: Arba Minch final report – Section 4.1
C. Dose rate of highly hazardous pesticides used on 500 hectares on two large cotton farms decreases by 50% by year 3.	LUCY FARM, 2014: 6.40 kg a.i. per hectare - endosulfan, Dimethoate & chloropyrifos AMIBARA, 2014: 3.87Kg of a.i. per hectare –dicofol, endosulfan and carbosulfan	Lucy 2015: 2.5kg a.i. per ha of endosulfan only ie .60% reduction AMIBARA 2015: 1.05kg in 2015, only endosulfan, ie 73% reduction	Annex 2.1: Arba Minch final report – Table 3
0.5 Production costs of Members of organic and IPM crop farmers' cooperative (35 men and 5 women) are 750 Birr per hectare or less by year 3, compared to 2475 Birr per hectare by farmers relying on pesticides (baseline).	*2475 Birr per hectare by farmers relying on pesticides* *NB: This cost was based on food or chemical sprays, but not full costs (oxen plough, labor costs for planting, weeding, re-planting, etc).*	In Genta Kanchama & Kolla Mulato, production costs for food spray (9650ETB and 5688ETB) were actually higher than for insecticide (4832ETB & 4567ETB). However due to significantly better yield, net revenues were higher (Genta Kanchama: 56,126ETB for food spray vs 17,627ETB; and in Kolla Mulato, 30,007ETB food spray, 17,893ETB)	Annex 2.1: Arba Minch final report – Table 8
E. Agricultural extension workers teaching IPM and food spray methods increases from 0% at baseline to 50% by year 3 (n = 48)	No official training or advice on IPM either by extension services or large farms	31 agricultural extension agents (8 women) from 9 villages, ie 64% of the total 48 extension agents, were involved in the FFS as facilitators. The remainder are Animal Health agents who were not involved in the project 4 plant health clinic staff (1 woman) teaching IPM methods, 17 plantation workers trained and applying the IPM methods.	Annex 2.1: Arba Minch final report section 6.1
F. At least 10 members of local communities are motivated to adopt new practices that protect or strengthen ecological processes and biodiversity, due to increased understanding of ecosystem services and the Ecosystem Approach, as demonstrated by testimonials.	0	Large cotton farm owners have phased out pesticide use (Amibara & Lucy) Smallholder farmers have adopted IPM methods for pest management; they can identify plants, trees and birds and have stopped spraying natural enemies. School teachers in Ziway and Arba Minch clubs are continuing ES walks and bird monitoring Parents of students are using PPE, putting pesticides out of reach, and making compost as a direct result of watching school club dramas.	Annex 2.1: Arba Minch report section 6.1 Annex 3.1: Ecotox capacity & impact report

The outcome has been largely achieved, with capacity developed among government agencies and scientists in designing and analyzing an appropriate and ecosystem-based ecotoxicological monitoring programme; and at grassroots level in identification and understanding of biodiversity and ecosystem services. 17 local people have received ecotoxicological field-level training and experience and are competent to repeat field monitoring and/or to train others; 6 national level experts have received training in ecotoxicological programme design and on the Ecosystem Approach and are competent to start to apply these in future projects. Through the co-financing project, but with broadened methodological approaches and training content provided by the Darwin component, 1976 farmers (171 women) from 9 villages in 2 districts have gained Farmer Field School (FFS) training in a simple agro-ecological alternative to pesticide application for pest control in cotton production; 17 commercial farm workers and 34 agricultural extension agents have assisted the FFS (training of trainers) and are now competent to spread their training to others.

The local Plant Health clinic (Ministry of Agriculture) representatives were active participants including conducting ecotox monitoring field work, contacting the flower farms and acting as an intermediary with the cotton farms to request information on pesticide use. In the last two years, the highest-ranking official opened the Farmer Open Days (Mr Katene Kawale, Gamo Gofa zone Administrator), showing high level of engagement and support from the local government authorities.

The project has documented a range of Highly Hazardous Pesticides (HHPs) currently in use in large-scale cotton in Arba Minch and smallholder vegetables in Ziway. This includes continued reliance (3-5 applications per season) on the persistent organic pollutant endosulfan (listed under both the Stockholm POPs and Rotterdam PIC Conventions). We also discovered 'fresh' DDT breakdown products in one sampling site at Lake Ziway shore, indicating recent use (possibly for unauthorised mosquito control, in contravention of Ethiopian law).

The Arba Minch work has shown disadvantages to both biodiversity and ecosystem services from conventional pesticide use on commercial cotton farms and advantages for ecosystem services of adopting a simple agro-ecological solution: Endosulfan use at one of the 2 commercial cotton farms studied has been shown to disrupt at least one regulating ecosystem service - the predator/prey population balance - via adverse impacts and smaller numbers of certain natural enemies of cotton pests (and hence a minor reduction in biodiversity), whilst having no discernible effect on pest numbers (the prey of the natural enemies). Applications of food supplements (based on ground, fermented maize) to attract predatory insects enhanced the same regulating service, with higher numbers of the same natural enemies and fewer (prey) pests found where the food spray had been applied. Indications from results from the other commercial farm and 2 smallholder farms are that the trend is similar (but unverified due to lack of statistical analysis). Both commercial farms and smallholder farmers have expressed interest in carrying out further trials of the agro-ecological approach to cotton growing that the use of food sprays offer, but commercial farms have raised the potential barrier of the cost/logistics of setting up large-scale food-spray production on the farm.

The project also showed the extent of nutrient and chemical-filtering services provided by Lake Ziway, and provided evidence of the continued use of POPs including endosulfan and DDT by smallholders and large cotton farms.

2.2 Impact: achievement of positive impact on biodiversity and poverty alleviation

Impact statement from logframe: The project will help to: reduce adverse impacts of pesticides on ecosystems in the Rift Valley wetlands, including the food chains on which key migratory birds depend; improve ecological quality of water resources; and foster communities' participation in addressing environmental harm.

It will help show how productive, agro-ecological farming practices that reduce reliance on expensive agrochemicals can conserve wildlife and protect ecosystem services while increasing farmer incomes, thereby improving the livelihoods, food security and welfare of rural communities.

Impact statement 1 has only partially been met, but in a very significant way via very strong successes in fostering community participation in addressing environmental harm potentially caused by excessive pesticide use.

Statement 2 has been met, with evidence comparing the impacts of agricultural systems demonstrating the positive effects of IPM and particularly food spray application on in-crop enhancement of key natural enemy populations and ecosystem service provision (and hence sustainability). There was also evidence of the diverse smallholder cropping systems being more diverse (birds and vegetation) than large-scale cotton production. The participation of farmers and plantation managers in collecting data has helped stakeholders adopt the conclusive evidence of benefits of agroecological approaches, though the two commercial farms still use endosulfan, frequency of application was reduced. They also avoided other pesticides like carbosulfan, dicofol and chloropyrifos. For smallholder producers, who replaced chemical sprays with home-make food sprays and achieved higher yields, net revenues increased by 67-200%, while at the same time achieving production of the highest quality, obtaining a price of 12 ETB per kilo for their Grade A seed cotton in 2016 (compared to just 10 ETB in 2013). These higher profits are largely attributable to the co-financing TRAID activities that helped farmers organize into cooperatives and build stores to sell their crop when conditions are better for them. The evidence documented and presented in the Darwin report has also contributed to many farmers from the 3 smallholder sites increasing their acreage under cotton in 2014 and 2015.

The results of residue analysis and biological monitoring of invertebrates in Lake Ziway provided evidence of the impacts of pesticide use on the lake and lake-side ecosystems, including from the illegal use of both DDT and endosulfan, both banned by the Stockholm Convention and with significant potential impacts on migratory birds and ecosystems. The experience of gathering this information helped further shape government perceptions of PAN Ethiopia's experience and relevance, and this evidence has been cited by government in its draft strategy on pest support services. Furthermore the evidence has helped PAN E engage new donors (including IDH) to implement a project on ecological pest management techniques on smallholder farmers who grow vegetables with the use of HHPs as evidenced by the Darwin project findings.

Anecdotal evidence and testimonials collected from local communities indicate changes in practices as result of the ecosystem walks/ outcrop monitoring, including that outreach by students on pesticide health hazards to their parents was having a positive effect in terms of parents adopting protective equipment, using compost, and in large farms phasing out pesticide use. Numerous quotes from local people demonstrate a new appreciation of the value of birds and trees as supporting healthy ecosystems and being an indicator of environmental problems.

2.3 Outputs

Output 1:	National researchers are able to design, conduct, interpret and report on scientifically robust research on biodiversity and ecosystem impacts of agricultural systems.		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 1.1: The quality of ecotox monitoring field project developed by the Core Darwin Team , increases by Year 3 as demonstrated by at least 50% improvements in scores on written outputs, and by at least 30% in pre and post training assessments	Inception training: pre-test average score 30% (4 participants) CDT average 'score' on first draft report: 3.52 (out of 10)	Post-test average score: 70% i.e. 40% improvement Final report average score: 5.96 (out of 10) i.e. 66% average improvement	Annex 1.1, PAN UK (2013) Inception Event report Annex 1.2: Scoring spreadsheet
Indicator 1.2: At least 10 local people (Local Monitoring Team, LMT, members) are able to	0 local people familiar with concept of 'ecosystem services'	7 LMT members (1 female) completed four ecotox field surveys	Annex 2.1: Final Arba Minch report section 6.1

conduct ecosystem services assessments by year 3 (from none at baseline), as documented by the completed species and ecosystem services surveying forms		10 local students (4M/6F) trained and able to sort invertebrates sampled from the lake into families for analysis	Annex 2.2: Ziway biological monitoring final report

Core Darwin Team

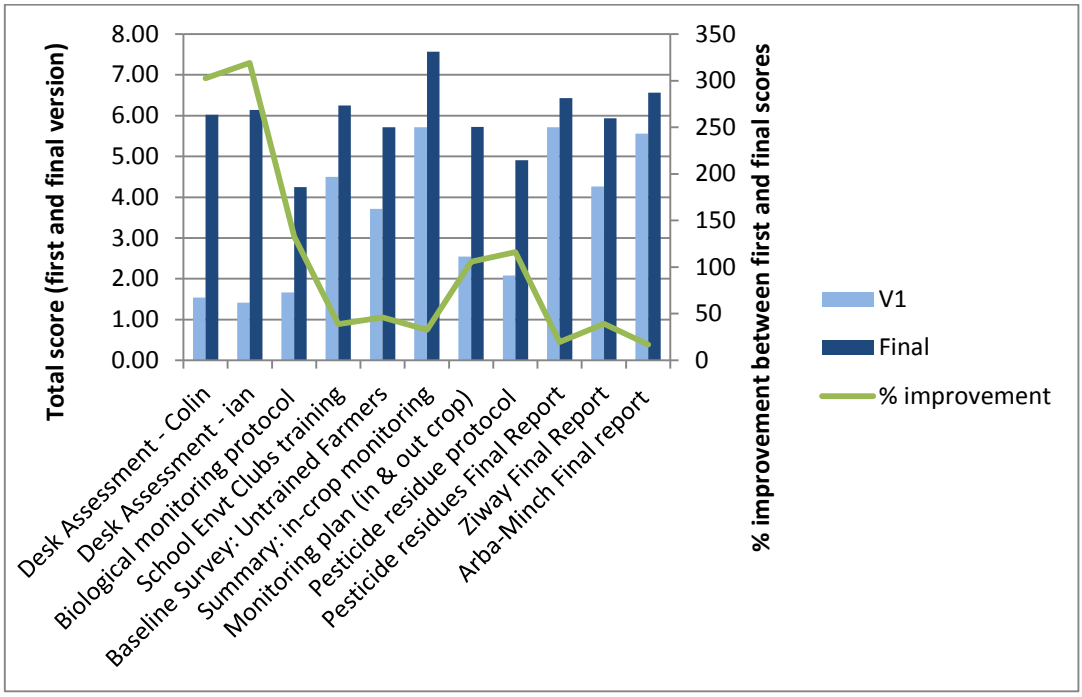
The project provided support through practical implementation of an ecotoxicological monitoring programme for agricultural ecosystems and landscapes by a 'Core Darwin Team' (CDT) of national Ethiopian researchers and practitioners. An initial face to face training in the UK by the UK experts from the Natural Resources Group documented a significant (average 40%) improvement in pre and post training knowledge.

A desk assessment of the risks to wetland biodiversity in the Ethiopian Rift Valley identified several possible causal factors including soda abstraction, aquaculture, agriculture and pollution. Investment by commercial and smallholder farmers in horticultural production had escalated around the lakes of the Central Rift Valley where cash crops such as cut-flowers, vegetables and fruit were being farmed using agrochemicals to increase yield potential. A 300ha horticulture and floriculture greenhouse complex, Sher flower farm, was established on the shore of Lake Ziway near Ziway town in 2005. This commercial farm abstracts freshwater from the lake and returns its wastewater through extensive reed bed areas of the littoral zone. The potential risk of adverse impacts from agrochemical residues on aquatic biodiversity was a significant concern at Sher because of its proximity to the lake and because effluent is discharged year round. Agrochemical run-off from numerous, irrigated, smallholder farms was also considered potentially hazardous to wetland fauna.

As the CDT began to design and implement monitoring activities, it became clear that scientific writing capacity was inadequate and didn't reflect the quality of field work (monitoring, community engagement, content and relevance of activities) being done. PAN UK and experts designed and applied an innovative, semi-quantitative scoring system for written outputs, based on five criteria which were used to provide structured feedback as well as the quantitative 'scores' which were used for M&E purposes.

i. Writing clearly for an external audience
ii. Clear structure and signposting
iii. Clear explanation of rationale and selection of methods, assessment criteria
iv. Careful analysis of results and drawing of conclusions
v. Good scientific style and referencing

Over the eleven technical reports that were scored with this system, the average improvement between first and final (corrected) drafts is 66%, demonstrating the impact of the technical support and feedback received from the NRG experts.



The figure above, showing the reports in chronological order on the horizontal axis, also indicates a gradually increasing improvement in capacity by the CDT, with higher scores for first drafts of reports (and less difference between first and final versions) as the project progressed.

An assumption in the original logframe that the CDT would benefit from previous capacity building in Ethiopia (during a previous Training of Trainers held in 2006) had to be revised after the tragic loss of one of the CDT members in year 1, and the fact that earlier trainees had moved to new positions and were not available for full time involvement in the CDT. The lower than anticipated access to expertise locally was exacerbated by the poor connectivity in Ethiopia via internet and telephone. Better communication between the CDT and the NRG during the design and planning of activities prior to commencement of field visits would have provided increased capacity building and better scientific outcomes. This was somewhat addressed by face to face contact in all three years, but budget constraints meant that only one of the NRG experts could visit in years 2 & 3, particularly affecting the Arba Minch work.

Local Monitoring Team

In line with the ecosystem approach adopted by the project, and particularly Principles 2, 11, and 12, the scientific work was decentralized as far as possible to ensure the consideration of indigenous and local knowledge and to involve local people. This was achieved by the establishment and training of 'Local Monitoring Teams' (LMT) in each of the monitoring sites comprised of local farmer-facilitators of the Farmer Field Schools (FFS), local agriculture plant health clinics, and teachers, with intermittent participation of extension agents, forestry agents, and FFS farmers. The Desk Assessment preparation included engagement of local stakeholders and training on ecosystem approach and ecosystem services concepts, during a 'Field Scoping Visit' conducted in September 2013 which involved 16 local participants, many of whom became regular members of the LMT, along with repeated trainings during NRG visits in 2014 (26 local participants, 5 female) and 2015 (4 local participants, 1 female). While the LMT members all actively participated and recorded data for the outcrop monitoring, they were still reliant on CDT experts for biodiversity identification (vegetation, birds). In reality, improvement in identification skills and systematic sampling practice was probably inadequate to run future monitoring visits unaccompanied.

It is possible to successfully incorporate ecotoxicological monitoring into locally designed crop protection field trials such as FFS and achieve meaningful results on the impact of pesticides (and other products) on pests and natural enemies. This approach provided evidence of negative impacts of the pesticide endosulfan on specific groups of natural enemies of cotton pests in commercially grown cotton in the Southern Rift Valley of Ethiopia. The farmer facilitators themselves conducted in-crop monitoring during the FFS sessions, and their

capacity to correctly identify both pests and natural enemies was evidenced through the logbooks maintained from the demonstration plots in the two large farms.

A total of ten local people were trained to identify and sort the aquatic invertebrate samples in Lake Ziway in addition to the Masters student conducting the research, educated final year students from Batu High School Environment Club, who were already enthused about the work and the ecosystem rationale. Following capacity building training given to the students by experts from NRG, their improved capacity in both sampling and taxonomic skills were evidenced by the data collection and identification tasks conducted independently, and a gradually increasing number of macro-invertebrate families recorded from the first to the fourth survey (refer to the Biological Monitoring Report, 2016).

Output 2:	Monitoring data presents robust evidence of pesticide use and its impacts		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 2.1 Ziway reports on pesticide use, survey of residue levels entering and residing in the lake, and biological monitoring of lake's littoral ecosystem is published by year 3	No evidence available	2 Ziway reports published	Annex 2.2 Biological Monitoring Report, PAN Ethiopia 2016 Annex 2.3 Pesticide residue status of Lake Ziway, Ethiopia, Littoral zone adjoining the Sher Flower Farm: Final report (Berhanu 2016)
Indicator 2.2 Arba Minch report on pesticide use and impacts in different agricultural systems published by year 3, comparing the net impact of IPM and conventional cotton farmers on natural capital (including biodiversity) and ecosystem services	No evidence available, although some reports on pesticide use (see Desk Assessment)	Arba Minch report published	Annex 2.1 Ecotoxicological & biodiversity monitoring within and between different cotton agroecosystems and in comparison to semi-natural forest areas, Arba Minch, Southern Ethiopia (Belay & Amera (eds), 2016)

Ziway report

Snap samples of water and sediment taken from the littoral zone of Lake Ziway in an area of commercial floriculture production were found to contain low level (trace) residues of organochlorine pesticides (OCPs). In water, residues of dieldrin, heptachlor, chlordane, endosulfan II, dBHC, and DDD were detected at concentrations ranging from 0.01 - 0.21µg/l in two wetland areas that received effluent drainage from the Sher flower farm at Ziway. Residues of αBHC and heptachlor epoxide (both at 0.02µg/l) were found in two wetland areas adjacent to the flower farm.

Sediment samples from the same wetland sites showed the presence of DDT and its metabolites. Methoxychlor was found at ppt levels at two sites - one within the flower farm drainage area and one outside it in a wetland conservation area. All DDT isomers and their metabolites were detected in the effluent drainage area at concentrations ranging from 0.28 to 4.38 µg/kg (d.w.). Sediment in this area was carrying nearly three times the amount of total DDT than that of sediment in an effluent channel carrying wastewater from the flower farm to the lake. A relatively high concentration of 4,4'DDT (23.5 ug/kg) found at a site within the conservation area was strongly indicative of current use. One OCP, the DDT metabolite 4,4'-DDE, was detected at trace levels in sediment underlying water abstracted directly from the lake.

The provenance of these OCPs in lake water and sediment was hard to ascertain. Several suggestions were advanced including known dissipation and transport mechanisms from sites of historical usage, current illegal usage for crop and public health protection (from stockpiles), and from washing of contaminated containers and articles. Of all the OCPs detected, only DDT was acknowledged as being in use by smallholders in the Ziway area. The presence of

trace OCP residues in the flower farm's drainage area is more likely a result of historical use and human activities than linked to a point source such as the flower farm effluent (past use cannot be ruled out though).

The risks of acute and chronic toxicity from trace amounts of these OCPs to aquatic organisms are small but there is an elevated risk of poisoning from fresh (un-degraded) DDT discovered in the conservation area. Of greater concern is the likelihood of bioaccumulation and biomagnification of persistent OCPs in the aquatic food chain, particularly fish that are consumed by piscivorous birds and humans.

The concentrations of total DDT in sediment found in this study are consistent with those observed in coastal regions and rivers/estuaries elsewhere in the world. Dieldrin concentrations found in wetland water was greater than the legal limits set by the GoE and EU for discharge in trade effluents. This snap-shot survey of pesticide residues at Ziway provides a limited picture of the chemical diversity, concentrations, spatial and temporal distribution of residues.

Over a one year period, four surveys of aquatic macro-invertebrates were made in wetlands either receiving or not receiving wastewater drainage from Sher farm. Macro-invertebrates sampled with sweep nets were identified to Family level. Differences in the number of Families present indicated that their diversity was slightly lower in wetlands receiving wastewater drainage. Despite some variation between surveys, mayflies, damselflies and beetle families were less well represented at drainage sites. The physico-chemistry of water at all sites was similar and not likely to be constraining species or populations.

Sorensen's Index of similarity at the Family level showed macro-invertebrate communities in wetlands outside the farm drainage areas to be very similar (91%). Compared with sites receiving drainage, communities were marginally less similar (82 to 86%) suggesting that either the farm effluents or human interventions were affecting the ecosystem and macro-invertebrate assemblages in some small way.

The Hilsenhoff Family Biotic Index was employed to estimate water quality using tolerance values of each taxon to pollution. All wetland sites measured up very closely. Nevertheless, the poorest score computed was for the drainage area, which is consistent with the site's water chemistry, where the highest mean pH, conductivity, TDS, PO_4-P, NO_3-N, and concentrations of pesticide residues in the water and sediment were recorded.

This study suggests that wastewater drainage from the flower farm is having a discernible, low-level impact on invertebrate biodiversity. All the signs point to nutrient pollution as the cause rather than toxicity from pesticide residues [n.b. only organochlorines were screened: whereas the majority of pesticides used in the region are of a more recent generation). Diffuse sources of nutrient contamination include clothes washing (PO_4) and cattle watering (urea in urine, N, P and K in dung), spasmodic activities that are widespread except in the conservation area. The flower farm is the one point source of nutrients to the lake, the magnitude of which can't be ascertained from a few incidental measurements. However the fact that the discharge of wastewater is continuous means that the nutrient loading of the wetlands must be considerable. Perennial discharge of untreated effluent to the lake is putting the wetland and lake at risk of eutrophication, and diminishing the quality of ecosystem services that the community should expect from the lake. The Ziway community uses the lake's resources for drinking, cattle watering, fishing, reed cutting, washing and recreation. Children swim and play in the effluent drainage area. There is an intimate livelihood connection between the lake and the surrounding community.

The residue monitoring presented considerable scientific and logistical difficulties which reinforce the need for developing alternative scientific approaches to assess pesticide impacts, in addition to chemical analysis that many regulators and researchers in developing countries focus on. The lack of laboratory capacity in Ethiopia, and particularly the lack of reagents and equipment, and the difficulty for non-academic institutions to import such materials, combined with difficulty in accessing pesticide use data on the flower farm, caused a delay in the residue results which in practice were developed in parallel with the biological monitoring instead of preceding and informing it as intended. The various partnerships developed both locally, with the Plant Health Clinic agents, and internationally, with IDH who were developing a large initiative on flower farms, allowed the project team to overcome this difficulty.

Arba Minch report

The use of endosulfan in commercial cotton growing in Ethiopia was documented in contravention of the requirements of the Stockholm Convention. Statistical treatment of results from plots in two large cotton farms showed a significant impact on certain cotton pest natural enemies, reducing their abundance in comparison to untreated cotton, whilst having no effect on the cotton pests themselves (no reduction in pest numbers compared with untreated cotton). A non-toxic food spray (developed by PAN UK in partnership with the Australian Cotton Research Institute and comprising ground maize meal + adjuncts) produced a very highly significant difference in abundance of the same natural enemies, increasing their numbers by comparison with untreated crop. The food spray also made a difference to pest numbers by comparison with untreated cotton, reducing pest abundance.

Vegetation monitoring was carried out to investigate differences in floral biodiversity between commercial cotton farms and small-holder farms growing cotton (amongst other crops), with natural forest as the 'baseline' comparator to represent the levels of biodiversity expected when human interference is absent or minimal. Vegetation monitoring was done using quadrat counts. The results demonstrated that using species richness alone did not highlight any notable differences in biodiversity between monitoring sites. The division of the commercial cotton farms into cotton-cropped area and 'ecotones' around field edges and/or drainage diches, etc was an important element in the capacity building for the CDT, but (as a result of the learning process) began too late to help draw out differences occurring within the commercial crop agro-ecosystem. Also, the data was not processed in a way that allowed statistical analysis of any potential differences between sites to be carried out; thus we cannot say whether any indications of a difference between sites is real. Similarly species composition (as estimated using the Sorenson Quotient) showed a good deal of dissimilarity between sites. This indicates a notable difference in species composition, but not in overall biodiversity between all sites; however, with this element of the data processing, only data from the 'ecotones' on the commercial farms was considered.

There are indications of differences in vegetation species richness between sites based on growth habit and although this points at differences in biodiversity in general (as woodland/forest generally has the highest biodiversity – faunal and floral combined – of all terrestrial habitats) it is not linked to higher biodiversity by any of the criteria used in this study.

The monitoring of birds used timed species counts. This did show suggestions of some differences in biodiversity between different sites, but (as with vegetation monitoring and the process of learning within the CDT) the data collected was not processed and analysed in a way that allowed for statistical testing of the results; thus no differences can be proven by the data collected.

Bird species richness did not appear to differ markedly between any of the monitoring sites. However, as with vegetation monitoring, commercial farm monoculture cotton areas were not sampled separately from the ecotone areas on the farm – rather, the ecotones and cotton cropped areas formed parts of the same transect walk and (until the final, 4th monitoring session) were not counted as distinct transects.

Nonetheless, there were some indications of differences in bird biodiversity between sites on the basis of the following:

a) The distribution of species when categorized as 'rare', 'uncommon', 'frequent', 'common' and abundant' (based on the time taken at any specific transect point for a member of that species to be encountered) between monitoring sites appeared to be different for the Semi-Natural Forest from any of the agro-ecosystem sites. There appeared to be more species found in the rare category than in any other for the semi-natural forest, with number of species declining as the 'rarity' decreased. All the agroecosystems tended to a more or less bellshape curve of number of species vs rarity.

b) The distribution of species across feeding guilds appears different in the semi-natural forest from that within any of the agro-ecosystems, with a distinct trend from fairly even distribution of species across feeding guilds in the forest towards 2 feeding guilds with the vast majority of species (insectivores and granivores) and much fewer species within the other feeding guilds

Calculations of livelihood benefits from different crop protection methods indicate that income of smallholder cotton farmers can benefit from a shift from use of pesticides to the more agro-ecological approach to cotton growing with use of food sprays. Commercial cotton farms examined appeared to show virtually no differences in net revenue from different pest management options, including untreated crops (for one of the two farms). Data from small-holder farms indicated that pesticide use provided the lowest net revenue; untreated cotton the mid-level revenue and food spray the highest. This trend was repeated on both farms where data was collected, however it is noted that these calculations are based on un-replicated data from trials with conventional pesticides and food sprays.

Problems encountered during the Arba Minch work included the need to limit the number of data collectors for the in-crop monitoring of pests and natural enemies to reduce variability from multiple observers, which was incompatible with the participatory FFS approach. The Darwin component also required a smaller number of pest control treatments (conventional chemical; no spray; one IPM treatment) to enable statistical analysis, which was not compatible with the discovery-learning, farmer-led approach adopted by the TRAID component in the first two years which trialled 2 different food spray recipes in combinations with and without neem seed extract. The project addressed this by focusing the Darwin monitoring in demonstration plots in the large farms rather than smallholder plots, once the most promising treatments had been narrowed down to a manageable number in 2015. These plots were managed and monitored by the same trained team of 3 -4 people from PAN Ethiopia and the Plant Health Clinic.

Another difficulty in setting up comparison plots with smallholders for the ecotox monitoring was finding farmers in the neighbouring fields (with similar growing conditions) who were willing to apply insecticides! FFS farmers no longer wanted to use pesticides at all, especially if they were aiming to gain organic certification. Finally, the availability of expertise and the need to respond to local community interest, led to the selection of birds and vegetation as the focus for the outcrop monitoring, rather than extending pest and natural enemy monitoring to the outcrop areas (ecotones within the agroecosystems and natural forest). By focusing on capacity building and limiting expert input into the outcrop monitoring, the scientific results are slightly limited. However, the project leaves behind a national coordinating team that is now experienced in the complexity of designing and implementing such a monitoring programme, as well as an engaged local community with a considerable increase in grassroots capacity (see Output 3 below).

Output 3:	Knowledge of the relationship between agriculture, pesticide use, biodiversity and poverty is held by local government and communities.		
	Baseline	Change recorded by 2016	Source of evidence
Indicator 3.1 At least 2000 cotton smallholder farmers participating in FFS and 2 plantation managers and 2 workers are able to identify beneficial insects and ecosystem services; and describe negative impacts of pesticides on ecosystem services by the end of the project	2013: 90 farmers trained in IPM	1993 local producers participating in FFS: 1976 smallholder farmers and 17 plantation workers able to identify pests and beneficial insects	Annex 2.1 Final Arba Minch report, section 6.1
Indicator 3.2 At least 50% of local community members surveyed at the end of local events (compared to less than 10% at pre-meeting surveys) can correctly describe the effects of pesticides on agro-ecosystems, and the consequences of their own production choices on	No community members engaged on pesticide impacts on agro-ecosystems	13 out of 15 female members of a spinning cooperative were able to describe impact of pesticides, and 6 identified environmental effects as well as health. 137 students complete ES walks and bird ID	Annex 3.1 Ecotox: capacity & impact Annex 3.2 Batu School

biodiversity and ecosystem services		Student weekly 'mini media' to 2500 students, and presentations to 1500 parents at school open day (June 2016) Farmer field days participants – 578 (94 women) in the 3 annual events following drama and presentations on pesticide impacts	Club report to ISD (2016) Annex 3.3a Darwin Output Note: Experiences with ecosystem services walks; Annex 3.3b NR Group/PAN UK Guidance Note: How to run an ecosystem services walk Annex 3.4 TRAID Farmer Field Day report

The community level awareness raising was delivered in parallel with similar activity under the TRAID project, which included focus in FFS on natural enemies and bees. The Darwin component focused on an ecosystem approach to reach out to rural communities, who are important in defining the social norms that influence individual farmers' decisions. Due to the delays in finalizing both the Arba Minch and Ziway ecotox reports (see Output 2 above), concrete findings from the Darwin research were only shared with communities at the end of the project. However the Darwin funding allowed PAN Ethiopia and ISD to directly work throughout the project period with non-farming members of the local community, and particularly with school students and teachers to build awareness and valuation of ecosystem services, particularly examining the role of birds in ecosystems, and cultural benefits of ecosystems to people.

Farmers

The Darwin project activities in relation to smallholder cotton farmers were delivered jointly with the co-financing TRAID project which delivered IPM and organic production training and support to pre-existing PAN Ethiopia networks of farmers in the area. The Darwin component was instrumental in bringing in an explicit 'ecosystem approach' and giving farmers a broader understanding of natural pest management as one of many ecosystem services that contribute to a healthy field and crop. 1976 smallholders and 17 plantation managers/ workers in the two large farms participated in the FFS. The FFS logbooks contain evidence of the ability of farmers to identify pests and beneficial insects, which were counted on a weekly basis. At the weekly sessions, facilitators guided discussions on pesticide impacts observed in the conventional plot, and shared their experiences as members of out-crop monitoring teams to introduce wider ecosystem services.

In annual Farmer Field Days, attendees were informed about the impact of pesticides on ecosystems both by the farmers (e.g. farmer drama presentation, Year 2) and by sharing results of the in-crop monitoring in smallholder and large cotton farms.

Community members

An innovative methodology of 'Ecosystem Service Walks' engaged local people and proved to be valuable in changing perspectives. The walks were designed to foster understanding of natural capital and ecosystem services in a practical way that directly relates to people's lives in the Rift Valley, whatever their level of schooling. Practical walks along approximately 500m transects were initially guided by NRG experts, who pointed out the multiple benefits from natural habitats by comparison with monoculture cultivated land, where a single benefit (food and fibre provision) dominates. School Environment Clubs at Ziway and Arba Minch high schools enthusiastically adopted the walks, as evidenced by quotes from both students and teachers, who continue to organize the walks after the project has ended. A brief guide on the methodology has been produced with practical instructions and will be translated into local languages and shared to the network of School Environment Clubs (both the two participating ones but also a further 25 in the ISD network). The students' and teachers' ability to identify ecosystem services and the potential impacts of pesticides and agriculture on these is

evidenced through their completed ecosystem service walk sheets, which show increasing ability to identify cultural, supporting and regulating services in later walks, compared to focusing more on provisioning services in earlier walks.

> "*An example of improvement during the second walk; there was a church in one of the sites in Ziway area and all the participants mentioned the church as a cultural service but during the second walk, the experts told us all that the church is a spiritual element and was constructed by human beings so it is not an ecosystem service. The ecosystem service is that how the people find it suitable for constructing a church. This brought a big change on how the participants think about the ecosystem services*." Extract from "Field training report: An ecosystem approach to ecotoxicology monitoring, Feb 2014"

Additional public community events held during the project duration included a presentation to a women's spinning cooperative and an organic producers cooperative. A survey of the women spinning group identified that 13 out of 15 association members were able to describe the impacts of pesticides on ecosystems.

Output 4:	Knowledge and data are presented that seek to influence policy on pesticide use		
	Baseline	Change recorded by 2016	Source of evidence
4.1 At least seven Ethiopian and regional government, farmer, academic, private sector and conservation stakeholders recognize the validity of and cite the ecotox monitoring results in their own publications; and make public commitments to further actions to address the external costs of pesticide harm at three national workshops	No initiative or report linking agriculture with biodiversity issues, or awareness of ecotox monitoring to provide evidence of agriculture impacts on ecosystem services	National policy makers workshop in Ziway in Feb 2015 results in public statements by all participants on the need for ecotox monitoring Pest Management Support Service - Strategy consultation meeting Sept 3-5 2015. the Arba Minch IPM-FFS in cotton which was then added in the draft guideline as a success story	Annex 4.1 Awareness raising workshop on safe use & mitigation of pesticides' negative impacts (PAN Ethiopia, 2015) Annex 4.2 Draft strategy document – extract (*NB this is a confidential draft so we have just extracted the relevant section & title page)*
4.2 At least 20 public officials or researchers working in other developing countries or at the international level make requests for information on the project results and methodologies; and at least 5 of these result in follow up meetings or exchanges of experience aiming at further adoption of the project approaches	No evidence of implementation of ecotox project on pesticide impacts	20 officials: CoPs, SAICM, Darwin workshop 5 follow up meetings/ exchanges: 1. IDH 2. Soaring birds/ GEF 3. Rotterdam Convention 4. Darwin Fellow exchange & future plans	Annex 4.3 Proposal to IDH Annex 4.4 Support letter (PAN E 2013) Annex 4.5 Rotterdam SHPF email Annex 4.6 Report on training for Darwin Fellow on non-pesticidal management and collaborative next steps (PAN UK, 2016)

National policy

Results from the project were presented at three national workshops to national stakeholders from policy, research and private sector.

1. A workshop on the impact of agrochemicals on migratory soaring birds was organized by EWNHS in April 2014. It was a regional workshop which included countries from along the Rift Valley Flyway (Red Sea Flyway). The Darwin project was presented in the workshop and was indicted as one of the regional projects which can play a role to reduce MSB poisoning; and was asked to provide a support letter to allow the project to be launched in Ethiopia by Bird Life International. A desk review of Ethiopian policy relating to agriculture and biodiversity was prepared jointly by PAN Ethiopia Director and EWNHS and disseminated in preparation for this workshop.
2. In February 2015, an awareness raising workshop on the responsible use and mitigation of pesticide impacts on MSBs and other biodiversity components was held in Ziway. Higher officials/decision makers from MoA, DLCOEA, FAO, Ziway Soil and Fishery research centres, HoA REC&N, EWNHS, Sher flower farm and Castle Winery took part in the workshop. Presentation about the residue analysis in Lake Ziway, ecosystem services walks with student and agro-ecological solutions with the use of IPM methods, the case of Arba Minch cotton farmers were done. Ecosystem service walks, along Sher flower farm side of Lake Ziway shore and the smallholders' vegetable production area, were conducted. This helped the higher official see what was happening on the ground. This created a discussion platform among the participants.
3. In September 2015, the Director of PAN Ethiopia was invited by the Ministry of Agriculture to participate in a national consultation meeting of experts to develop a pest management support system. The review of success and failure stories of pest management systems in Ethiopia were reviewed, and the PAN Ethiopia experience in Arba Minch was included in the draft strategy document produced.

At the local level, the excellent relationship and support from the Ministries of Agriculture and Health has led to significant shifts in the practical delivery of extension advice. The extension agents, supported by the FFS facilitators and PAN Ethiopia, have been trained and experienced for themselves the better results from agro-ecosystem approaches and now regularly advise farmers to inspect their fields and avoid excessive pesticide use.

At the national level, the policy engagement provided new information for higher officials who didn't have information about what was happening on the ground. They hear most of the information via reports, so the project (and particularly the ES walk and visit to smallholders farms during the workshop in Ziway) created the chance for them to see what really is going on, which shocked them and has been an important influence on subsequent consideration of regulations and pesticide handling mechanisms.

International policy

At the international level, the project has been well received and has triggered additional actions from international donors including:

- A regional BirdLife International project to be funded by the Global Environment Facility seeks to intervene in key sectors (including agriculture) in different countries in the region. Partly as a result of the momentum generated by the Darwin project, agriculture was selected for action in Ethiopia, and PAN Ethiopia provided a co-financing letter in 2013 to help the project to be launched. The project will be managed by a key Darwin partners, EWNHS, and PAN Ethiopia will be involved in disseminating and continuing to apply the methods and approaches developed during the Darwin project. http://migratorysoaringbirds.undp.birdlife.org/en/sectors/agriculture
- IDH – the sustainable trade initiative of the Dutch Government (http://www.landscapesinitiative.com/en/selection-of-4-other-landscapes): IDH are currently running a sustainable landscapes project in the Continental Rift Valley (CRV) which brings public and private actors together to invest in sustainable land and water management. PAN UK presented the results of the project to IDH in 2015 and as a result, the project now includes an element to "facilitate dialogue and support relevant action among regulatory and key stakeholders on the issue of water and food quality in relation with pesticide use among smallholder horticulture farmers in CRV". IDH have asked PAN Ethiopia to conduct further data collection of pesticide impacts from the vegetable and floriculture production. This information will be used to develop targeted interventions on the ground to tackle

pesticide use and to develop policy advice for the Ethiopian government and floriculture industry.

- The Rotterdam Convention: PAN UK and PAN Ethiopia shared findings from the project at the Conference of the Parties to the Rotterdam, Stockholm and Basel Conventions in 2015. Following this, the Secretariat of the Rotterdam Convention asked PAN UK to prepare a toolkit – drawing on the project approaches – to support governments, civil society and local communities to record and report environmental incidents associated with pesticide use.
- India Darwin exchange; In 2014, Dr Barbara Smith, project manager for Darwin Initiative project Enhancing the relationship between people and pollinators in Eastern India ("People & Pollinators") then at the Game and Wildlife Conservation Trust (GWCT) met PAN UK's project manager, and learnt about the Ethiopian ecotox and alternative pest management activities. As a result, she then included PAN UK as one of the host trainer organisations for the Darwin Fellow training programme for Indian project coordinator. Dr Parthiba Basu. Dr Basu, from the Zoology Dept at Calcutta University and Director of the Centre for Pollination Studies, came to PAN UK in May 2016 for 2 days' training and experience exchange on technical, extension and policy aspects of non-pesticidal pest control. This was a hugely fruitful experience for both organisations, with several mutual lessons and recommendations for learning resources for new Darwin project teams and DI managers identified as outcomes and joint collaboration proposals already underway (see Training Report). Dr Basu is especially keen to make use of the ecosystem services walks method with his farmer outreach team and with university students and lecturers, including those on the 6 month postgrad course on agroecology.
- A concept note for a South-South experience exchange study tours between Darwin project teams and collaborators in Ethiopia and India is being prepared, with the Indian team interested to learn about (i) how the Ethiopian project has taken an ecosystem approach and (ii) using and testing the food spray method for enhancing biological control. Partners in both Darwin projects, including Coventry University's Centre for Agroecology, Water & Resilience (CAWR), at which Barbara Smith now works, are developing funding proposals for testing the food spray method in smallholder vegetable production, as part of IPM implementation, in Ethiopia and India, and possibly a Latin American country too.
- Darwin Initiative projects experience sharing workshop, 19th April 2016 London: very useful exchange with around 35 old and new project managers, of which over half took this project's leaflets and updates. PAN UK fully agrees with the main recommendation to DI from project managers to facilitate a learning space for projects to share experiences, tips and resources. Participants from 3 projects asked PAN UK to write a short guidance document on how to run ecosystem services walks. Several others agreed that effective report writing is a challenge for many project partners and suggested PAN UK write a mini-learning note on the quality-control/improvement system we developed for helping partners write better technical reports and info for external audiences. The Darwin project on sustainable smallholder green bean production in Tanzania and Malawi is keen to find out about the food spray method, FFS learning exercises and possibly even trial the food spray in 2017-2018 once PAN UK's training manual is written. Two other projects asked about collaboration on vulture poisoning ecotox research and mitigation (due to pesticide baits put out for predators of livestock and diclofenac veterinary drugs) and awareness raising for conservation aims in southern Africa. PAN UK has already been contacted on this subject by Zimbabwean contacts via University of Cape Town's Pesticide Risk Management diploma course for professionals and these combined interests could form the basis for funding proposal preparation
- Dissemination of project findings was delayed but is continuing, with summary articles on both the Arba Minch work and Ziway work in preparation for the August issue of *Pesticides News* and lessons papers on both the ecosystem service walks, and on the capacity building aspects of the project, being disseminated through FAO and other networks.

3 Project Partnerships

The Lead Institution (PAN UK) worked very closely with the main implementing partner (PAN Ethiopia) with joint decision making and delivery of the project, including on project and

budgetary management and joint reporting and technical oversight. This was done through annual face to face visits by Dr Stephanie Williamson to Ethiopia in May 2014, March 2015, and February 2016 which included technical support during field visits to the FFS sites in Arba Minch information provision on IPM for collaborators in the Arba Minch Plant Health Clinic, liaison with the teacher coordinators and four students from Batu High School Environment Club in Ziway town and joint planning sessions in PAN Ethiopia's office in Addis Ababa. An article on the Plant Health Clinic's successful mango IPM project with smallholders was included in the June issue of PAN UK's journal *Pesticides News*

Two members of the NR Group, Prof. Ian Grant and Dr. Colin Tingle, worked closely with PAN-UK on project delivery, providing training and guidance sessions in the field in Ethiopia and distance guidance to the CDT via eMail, skype, Dropbox, etc.), with a focus on technical aspects of and capacity building for design, implementation, analysis and reporting of an ecotoxicological monitoring programme (particularly to assess biodiversity impacts) and capacity building in the Ecosystem Approach.

The Ethiopian Biodiversity Institute (EBI) and the Ethiopian Wildlife and Natural History Society (EWNHS) were engaged from the inception of the project and delivered trainings, organized joint workshops and led the Local Monitoring Teams (LMT) in the outcrop field monitoring of vegetation and birds as indicators of biodiversity and ecosystem services. This model of a national coordinating team was very effective in transferring capacity for relatively simple field ecotox techniques to communities and local people, while also allowing capacity to be built in Ethiopia for the more complex steps of designing a valid study and analysing and discussing the findings. Difficulties were encountered with timeliness and organization of work, due in large part to the significant institutional and budgetary constraints imposed on Ethiopian NGOs by the government. Our NGO main partner was not able to directly contract the individuals needed from their hosting institutions, which made it impossible to strictly enforce deadlines and technical requirements for reports. This contributed to delays in finalizing outputs and to a disproportionate burden falling on PAN Ethiopia and particularly the responsible Project Officer, who ended up writing much of the Arba Minch final report alone.

The partnership with Addis Ababa University (AAU) has been affected by the unexpected death of Dr Emiru Seyoum, the main collaborator and CDT member, in 2013, which directly caused problems with the timely delivery of field reports, and access to laboratory facilities for the pesticide residue monitoring. The latter problem was overcome with a change request to re-direct funds for consultancy and engagement of the Ministry of Agriculture/ Laser laboratory for the residue analysis work, but this caused delays due to the need for unanticipated procurement. However, the cooperation with AAU has continued, with participation of faculty members in project events and engagement and supervision of a Masters student who performed the biological monitoring in Lake Ziway.

The Institute for Sustainable Development (ISD) led the schools work, including supporting teachers as LMT members, and leading ecosystem services walks and training on IPM methods in schools with student members of School Environment Clubs. Their long history of working with teachers and students in the project area was an important factor in accessing channels such as school 'mini media' sessions and existing structures for efficiently rolling out the ecosystem service walks.

The Horn of Africa Regional Environment Centre and Network was approached in Year 1 as a potential partner and this partnership has developed further in Year 2, with a joint workshop for policy makers in February 2015 and use of their habitat conservation sites on Lake Ziway for the biological and pesticide residue monitoring. The partnership between HoA REC&N continued and conducted and both organizations conducted a survey on pesticides use in the Central Rift Valley areas on smallholder farmers with funding from HoA REC&N.

4 Contribution to Darwin Initiative Programme Outputs

4.1 Contribution to SDGs

SDGs 1 (Poverty) and 8 (Decent work) – please refer to section 4.3.

The project has also contributed to improved knowledge on the impact of pesticides on life below water (SDG 14) and on land (SDG 15), through the monitoring of biological diversity in Lake Ziway, and on biodiversity in agricultural landscapes in Arba Minch. While the delays have limited the opportunity to press for action to ensure clean water and healthy landscapes, this pollutant assessment provides evidence of e.g. use of endosulfan banned under the Stockholm Convention, and is therefore a strong basis for both these SDGs and also SDG 12 and its indicator on implementation of agreed multilateral agreements.

The participatory approach with strong involvement of schools and local government services contributes to SDG 17 by establishing a strong basis for continued partnership on reducing environmental impacts of pesticides.

4.2 Project support to the Conventions (CBD, CMS, CITES, Nagoya Protocol, ITPGRFA)

The project has contributed to the following Aichi Targets of the CBD (see Annex 4):

- *1: People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably:* the extensive grassroots public events and activities have contributed to a higher awareness among school teachers and students, farmers, women spinners, of the value of biodiversity and ecosystem services to their communities, wellbeing and livelihoods and on the ways in which reducing pesticide use contributes to conservation and sustainable use of biodiversity. This has strengthened and been strengthened by the parallel TRAID-funded project which demonstrated IPM alternatives to pesticide use, with farmers expanding their cotton cultivation areas and large farms achieving important reductions of POPs and HHPs.
- *4: Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits*. The Darwin evidence has contributed to the shift in discourse on sustainable agriculture in the Ethiopian Ministry of Agriculture, by reinforcing and supporting a new policy on pest management, with a new focus on ecosystem approaches and IPM.
- *7: Areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity*. Through engagement with both the flower farms and large cotton farms, as well as with smallholder cotton producers, the project has directly contributed to the reduction in use of pesticides and specifically globally banned POPs such as endosulfan and DDT, for which the project gathered evidence of use. It has also contributed significantly to a localized interest and uptake of IPM in cotton growing and, via introduction of a simple agro-ecological approach to pest management, resulted in a significant number of smallholder farmers reducing pesticide use and switching to an ecosystem service enhancing approach.
- *8: Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity*. The evidence of impacts of nutrient discharge from the flower farm on aquatic invertebrates in L. Ziway has contributed to a dialogue in the region and among farm owners on the extent and value of ecosystem services provided by the lake. While the project has not documented pollution abatement in the short time period, it has used local workshops and higher level engagement to support further initiatives, such as a planned landscape scale initiative by IDH in the area. Work with cotton farmers in the Arba Minch area has brought pollution levels from the insecticide Endosulfan down in trial fields where no chemical sprays were used or food sprays employed instead.
- *19 Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.* The project has built capacity at different levels to generate scientific knowledge about ecosystem functioning and biodiversity in both agricultural landscapes (Arba Minch) and lake ecosystems (Ziway), with detailed final technical reports shared with stakeholders. It has also undertaken research (designed and implemented by the project team) that has improved local knowledge of pest/predator dynamics and diversity in cotton and demonstrated how to improve ecological functioning via an simple agro-ecological approach to pest management.

4.3 Project support to poverty alleviation

The project, along with its co-financing component funded by TRAID, has directly contributed to improved incomes among 1976 smallholder farmers who decreased their production costs through savings on pesticide inputs, while increasing the price of their cotton production and achieving top grading for the quality of their cotton. While the TRAID-supported experiential learning process and assistance in organizing into cooperatives has largely driven this work, the Darwin component has contributed to strengthening the rationale and message to farmers to adopt IPM by making explicit the ecosystem approach and encouraging not just farmers, but entire rural communities, to perceive and value the full range of ecosystem services that may be disrupted by inappropriate pesticide use. These messages strengthen the primarily health and economic messages currently being used to promote IPM; and are also very valuable for certification bodies and supply chains to be able to quantify the full benefits of adoption of sustainable agroecosystem approaches.

> *"The working towards insuring environmental sustainability is not a matter of luxury. It is rather a matter of life and death. It is a matter of alleviating poverty."*
> Secondary School Environment Club report to ISD, 2016

4.4 Gender equality

Women farmers were involved in the FFS (171 women) although with much lower numbers than the male participants. Lesser involvement of women in field based activities such as IPM was a cultural barrier, in that there is generally a relatively low participation of women in cotton production in the project area. Given the relatively low participation in field activities, the project supported establishment of the women's spinning association, initially with 20 members from each of 3 villages but which rapidly grew to around 30 each with new members registrations (90+ spinning association members).

One of the seven LMT members in Arba Minch field monitoring team was a woman; and six of the ten students involved in biological species sorting were women. Female students were also involved through the ES walks, with eight of the original twelve who were trained by ISD in Dec 2014 being female.

4.5 Programme indicators

- Did the project lead to greater representation of local poor people in management structures of biodiversity?
- Were any management plans for biodiversity developed?
- Were these formally accepted?
- Were they participatory in nature or were they 'top-down'? How well represented are the local poor and women, in any proposed management structures?

While the project did not develop formal biodiversity management structures or plans, through its close relationship with the co-financing farmer training project, it was able to strengthen a shift towards agricultural and pest management approaches in the area. The Darwin contribution was particularly valuable a) in generating statistically analysed data on pest and natural enemy levels to support the more experiential experience of participatory FFS and b) in expanding the reach of these farmer-focused initiatives to the wider community through the ES walks and work in schools. The shifts in pest and agricultural management proposed were highly participatory, with the project giving voice to farmers, children, and women and creating strong relationships with local governmental services and commercial farms.

- Were there any positive gains in HH income as a result of this project?
- How many HH saw an increase in their HH income?
- How much did their HH income increase (e.g. x% above baseline, x% above national average)? How was this measured?

Beneficiaries: 1805 men and 171 women farmers.

The average cotton yield per hectare of the cotton grown with the use of IPM methods was 32.43 quintals in the 2015 production season, compared to the baseline yield which was 16.85 quintals per hectare, ie a 92% increase. Whilst yields fluctuate from year to year (e.g. based on rainfall / climate or pest levels), the similarly high yields documented in the previous year (36.50 quintals per hectare in 2014) indicates a consistent improvement. The yield improvement between the smallholder plots producing food spray, IPM, and pesticide sprayed cotton showed even greater yield increases of between 60% and almost 200%.

Members of the Shelle Mella Organic Crop Producers' Cooperative had agreements with Arba Minch ginning factory and ginned their 60 ton cotton with an output of 22.85 ton lint cotton. The lint cotton is being tested for its staple length and other parameters by TIDI and its price was determined to be 35 ETB per Kg of lint cotton. Farmers who are not in the cooperative received 10 ETB/Kg of seed cotton from the local merchants, up to 12 ETB/Kg if they were able to sell to the cooperative, i.e. 350% increase in income as compared to non-trained farmers.

Finally, the cooperative members sold the cotton seed to edible oil refiners for a total of 219,870 ETB; while they plan to sell prepared cotton seeds to farmers for the next cropping season, which is priced in the local market in the last three years at 50 ETB/kg. The cooperative planned a price lower than that to benefit both members and non-members in the area who will save money on seeds.

With regards to certification, continued discussion was held with Control Union, Ethiopia about the requirements. They also visited the farms and had discussions with the farmers about the control systems that need to be developed which will be their cotton production guidelines and principles as long as they are being certified. ICS is being developed in consultation with the farmers and field agents. Solidaridad took the lead in developing the internal control system.

4.6 Transfer of knowledge

Did the project result in any formal qualifications?

i. How many people achieved formal qualifications?
ii. Were they from developing countries or developed countries?
iii. What gender were they?

Output 1 of the project explicitly addressed transfer of knowledge and capacity to people in developing countries. The capacity increase in PAN Ethiopia and CDT was demonstrated by the successful (if delayed) completion of the project by a team who were all new to ecotox monitoring, rather than the project being able to recruit individuals who had been previously trained in 2006 as was originally assumed.

One (male) Ethiopian is using the field work as his Master's thesis from Addis Ababa University (due to graduate in 2016-7). A second (male) member of the CDT will transfer the knowledge he gained during the project to students of Environmental Science at his new University job, including getting students to carry out ecosystem service walks and bird monitoring.

4.7 Capacity building

i. Did any staff from developing country partners see an increase in their status nationally, regionally or internationally? For example, have they been invited to participate in any national expert committees, expert panels, have they had a promotion at work?
ii. What gender were they?

Please refer to section 2, Output 1, which describes the explicit capacity building activities and results of the project.

PAN Ethiopia gained an increase in status and particularly stakeholder perception of their 'added value' in issues pertaining to pesticide contamination and monitoring. For example, the invitation letter to the Horn of Africa workshop in 2014 is addressed to PAN Ethiopia and explicitly acknowledges their Darwin work: "*since your organization is directly involved in the regular water quality monitoring or in the capacity building of local laboratory experts".*

Similarly, the Director was invited to participate in a national consultation in 2015 on the new pest management strategy, in recognition of the relevant experience both in IPM and in documenting positive impact of this on ecosystems and biodiversity. He is also invited to present project work in Arba Minch at the International Congress of Entomology in Orlando, Florida, in September 2016.

4.8 Sustainability and Legacy

Due to the high effort put in by the CDT to actively engage relevant local communities and agriculture services, the shift from pesticide based pest management to agro-ecological approaches amongst smallholder and commercial cotton farmers is likely to endure, particularly if increased use brings more evidence of monetary benefits to livelihood improvements.

The Ethiopian Ministry of Agriculture included the IPM-FFS work in Arba Minch area as a case study in the draft strategy for National Pest Management Support Services. This strategy will guide the provision of pest management support by the Ministry of Agriculture for the whole country, with potential to expand the achievement of the Darwin and TRAID projects in Arba Minch in engaging extension agents in monitoring natural pest regulation and other ecosystem services as part of a system to promote agroecology. Evidence of continued endosulfan and DDT use will further help justify the need for the government to reduce reliance on pesticides.

Two school environment clubs were engaged in ecosystem service walks and bird identification, and plan to continue monitoring in wetland and lake areas nearby. Based on the experiences from the two schools, ISD plans to expand the activity to other schools as it is working with more than 20 schools in the country, including through translation of the Darwin Initiative project's guidance on ES walks into local languages.

5 Lessons learned

- We underestimated the time and resources required for effective training, guidance and mentoring by UK-based experts in delivering a sound monitoring programme in a way that was participative, learner-led and thus relevant rather than being 'expert taught' by cultural outsiders. Face to face contact time with the NRG experts was limited to once per year, and given the complexity of the subject and unreliability of communication networks, was inadequate to deliver this complex and ambitious project in a timely manner and to the standards hoped.
- Ethiopian scientists and researchers were able to design and deliver largely rigorous and convincing biodiversity and ecotoxicological monitoring science, and the involvement of local people in data collection showed that the field methods themselves can be implemented by citizen scientists. The areas which required the most support from the NRG experts (and remain capacity gaps even after project completion) were in designing the sampling protocols and approaches: data management and statistical analysis; and putting the Ecosystem Approach into practice.
- Residue analysis capacity is very limited, and severely disrupted project timing. Few labs are accredited to undertake residue chemistry, and severe underfunding of local university facilities means they may not be able to maintain analytical equipment, replace glassware, and have trouble sourcing spares and specialist gases (plus problems of currency exchange and delays clearing imports). Residue work should be clearly described at the time of project preparation, with scrutiny of proposed labs and proposed arrangements for the cold chain from field to lab; honest appraisal of likely budget needs and contractual arrangements with the lab and specialists (developing a sampling plan as well as residue chemists) including time limits.
- Considerable, unplanned support and mentoring was needed to improve partners' report writing skills, both for scientific and wider, external audiences. We developed a simple

quality control system to help identify aspects requiring improvement and to assess progress. An effective data collection and interpretation system is as important as the monitoring methods and data itself.

- There is inherent incompatibility between formal scientific monitoring requirements on methodology and aims to make it participatory and involve local farmers and community members, a dilemma also recognised by several Darwin projects at the sharing workshop and Fellowship Exchange in 2016. This was overcome by focusing research activities in a smaller number of large farms, while continuing wider participation through complementary informal monitoring methods (ecosystem service walks).
- There are significant overlaps between the biodiversity-origin Ecosystem Approach and the FFS approach, and the participatory trials of the "food spray" method to enhance biological pest control engaged and enthused farmers, field extension agents and the local Board of Agriculture and showed how yields can be increased for low input systems and/or maintained for high input large cotton farms, without needing to use HHPs.
- The Ecosystem Service Walk methodology was readily adaptable to existing networks, such as extracurricular High School Environment Clubs, pioneered by collaborator NGO Institute for Sustainable Development. These proved a fantastic learning forum for environmental awareness and a powerful outreach channel to farming parents.

5.1 Monitoring and evaluation

A Mid Term Review was conducted in November 2015 which resulted in a revised and simplified logframe and indicators. In most cases, the original outputs, indicators and assumptions were not substantively changed, but were found to be inadequate to fully describe the project logic, and were replaced by more detailed and specific indicators. While the review resulted in a more streamlined data collection and reporting process, the net gain in time and effort was offset by the significant effort and time that was allocated to M&E in Year 2, in order to prepare for and host the MTR and the subsequent process for all partners to agree the proposed changes in the logframe. The revised framework was however very helpful for developing and guiding participatory activities at community level, for example in preparing post-meeting satisfaction and impact surveys, and in focusing the key messages which were included in final project publications and communications materials.

One substantive change in project design related to the original output "*National Biodiversity & Agriculture Stakeholder Group established to provide supportive policy environment for sound agricultural practices that conserve biodiversity"*. This approach was revised following a review of agricultural and biodiversity policy in 2014 by the EWNHS which identified a number of institutions and forums that already have responsibility for stakeholder engagement. This new Group was therefore not considered necessary or efficient, and the project adopted the objective to achieve the same result by engaging with existing government consultation and engagement processes and events (refer to Output 4, Indicator 4.1 above).

The MTR make four key recommendations, which were all followed up and implemented, with the exception of the fourth.

Recommendation 1: Revise the logical framework paying particular attention to the outcome level indicators which currently are not SMART ensuring the project is capable of capturing both the poverty and biodiversity benefits expected to be achieved by the project. A proposed draft logframe was developed with the team which requires more work from the team but is a substantial improvement. Response: The draft logframe was adopted in year 2.

Recommendation 2: Develop a coherent communications strategy to ensure the results of this ecotoxicological monitoring can support the government and private sector to change practice that is beneficial to environment, human health taking account of economic growth targets. This should include a review of the relevant actors that could support this work and a review of the types of products that could support this work including policy briefing notes. Response: implemented in year 3 (refer to Output 4 in Section 2).

Recommendation 3: Consider lifting the sights of this work to not only influence Ethiopian government policy but to present the results of this work to Ethiopian donors such as DFID.

Consideration will need to be taken of how to present this work to an acceptable international standard to make greatest impact. Response: Project work and findings were disseminated internationally in Year 3, including at the combined chemicals and wastes convention Conferences of Parties in May 2015, and Strategic Approach to International Chemicals Management (SAICM) conference in September 2015 (refer to Output 4)

Recommendation 4: Seek to understand the lessons emerging from other groups on how to influence changes in practice in flower farms in Ethiopia and elsewhere in East Africa. Expand the point of reference to include issues outside of just pesticide use e.g. water use, Fair Trade etc. Other comments on progress not covered elsewhere. Response: We felt that influencing practice in flower farms is beyond the scope of this project, and would not be achievable within the budget and timing constraints already being faced in completing the original activities. Despite efforts by PAN Ethiopia, none of the flower farms around Lake Ziway (including the one where residue sampling and invertebrate monitoring was done in its effluent channel) have been willing to supply a list of the pesticides they currently use and therefore the project team remains in the dark about use patterns and possible risks and impacts. Nonetheless, PAN UK is now engaging with Dutch donor IDH (Sustainable Trade Initiative) at the international level to consider possible collaboration on supporting flower farms around Ziway to phase out specific HHPs and replace with more IPM methods, as well as address the highly risky pesticide practices by smallholder vegetable growers in the same area. PAN UK's Director and Staff Scientist were invited by IDH to present guidance and recommendations on pesticide issues and IPM to IDH staff in the Netherlands in Feb and May 2016. At the latter meeting, PAN UK presented a graphical representation of 'How to move up the IPM ladder' for IDH staff and colleagues in the Floriculture Sustainability Initiative, with a case study on flower farms in East Africa. This is being developed into a Theory of Change, with support from Darwin 'People & Pollinators' project managers Barbara Smith and Parthib Basu, with whom PAN UK shared the conceptualisation as part of Dr Basu's Darwin Fellowship training.

5.2 Actions taken in response to annual report reviews

The reviews of our annual reports provided useful feedback and allowed us to improve both project delivery and reporting. The issues raised in the review of the first report were summarized and discussed in a follow up skype meeting which was instrumental in helping us prepare for hosting and assisting the Mid Term Review. A similar process was followed after the second review, with the following (largely reporting) issues addressed as follows:

Clarify relationships between DI project and the subregional GEF project on the effects of agriculture on large soaring birds – please refer to section 2.3, Output 4 of this final report.

Investigate (and implement) ways to encourage more women farmers to be involved in the farmer field schools – please refer to section 4.4 of this final report.

Provide an update on progress with sourcing unconfirmed / unidentified matching funds (or the effect of their unavailability on project implementation – please refer to section 7.2 below.

6 Darwin identity

Darwin identity has been promoted through all the communication and dissemination activities conducted by the project, with consistent use of the Darwin Initiative logo and a statement recognizing the UK Government as the source of support for the project. The most relevant activates and materials developed include:

- Newsletters: Two project articles published in the Darwin newsletter (June 2014 and June 2016); and blog post on the project by the external MTR reviewer https://darwininitiativeuk.wordpress.com/2015/06/05/sustainable-fashion-and-biodiversity/ . Ethiopian Natural History and Wildlife Society newsletter (2013)
- PAN UK website and Annual Review; plus leaflet and banner displayed and distributed at international meetings including Conferences of Parties for Basel, Rotterdam and Stockholm convention and SAICM, where government representatives took 50+ project leaflets and inquired about the ecosystem service walks. 20 leaflets distributed at Darwin projects lesson sharing workshop April 2016 London.

- 3 articles for Pesticides News on the Darwin project in production (August issue), plus two on the Indian pollinators project by Dr Basu on pesticide impacts on native Indian honey bees, and an interview /film with him in production
- Community field workshops and meetings including public meetings, Farmer Open Days, spinner and organic cooperative meetings
- Presentations to national policy workshops in Ethiopia including a workshop on Agro-chemical Poisoning and Conservation of Migratory Soaring Birds along the Rift Valley/Red Sea Flyway (April, 2014), water quality monitoring (January 2015), policy maker workshop in Ziway (February 2015) and national Pest Management consultation workshop (Sept 2015)

7 Finance and administration

7.1 Project expenditure

Project spend (indicative) since last annua report	2015/16 Grant (£)	2015/16 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)				
Consultancy costs			-14.04	The additional costs were to cover input from a statistical expert to review the methodology and data - this was necessary partly because the death of Dr Emiru Seyoum from Addis University, who was envisaged to lead on this, left a gap in our team, but also because the because the food spray trials were quite complicated in lay-out
Overhead Costs			9.49	The independent audit has not been completed yet, so £1,500 earmarked for this has not been spent
Travel and subsistence			50.42	Proposed number of trips were conducted, but we managed to share costs with TRAID, and also piggy-back on other visits - e.g. Keith Tyrell's combined final visit to Ethiopia in early 2016 coincided with attendance at a Global Coffee platform meeting, which covered travel costs.
Operating Costs			0.00	
Capital items (see below)			0	
Others (see below)			20.15	Costs for attending international conferences to share findings kept low.
TOTAL	**£89,58**	**£87,58**	2.23	

Staff employed (Name and position)	Cost (£)
Stephanie Williamson (PAN UK)	17,40

Keith Tyrell (PAN UK)	
Geremew Tereda (PAN UK)	
Tadesse Amera (PAN Ethiopia)	
Birhanu Genet (PAN Ethiopia)	
Mifta Ahmed (PAN Ethiopia)	
TOTAL	**£35,748**

Capital items – description	Capital items – cost (£)
TOTAL	

Other items – description	Other items – cost (£)
TOTAL	

7.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
TRAID	
JJ Trust	
TOTAL	**248,23**

Source of funding for additional work after project lifetime	Total (£)
Please refer to Output 4	
TOTAL	

7.3 Value for Money

The project was able to maximise efficiencies through fewer, longer trips by PAN UK and NR group to provide in person support, generally staying at least 2 weeks at a time to minimize travel cost and carbon for a given time in country.

The ecotox monitoring techniques were able to use local materials wherever possible – netting, boots, etc, and the use of a local laboratory for residue analysis was the best economic option once it became clear that we would not be able to use laboratories in AAU as originally planned..

Field work in Arba Minch benefited significantly through collaborations and co-financing projects, including the existing networks of FFS for the in-crop monitoring; and the ISD School Environment Clubs that were already in place and with a history of working on pesticides and sustainable agriculture issues.

Annex 1 Project's logframe, including indicators, means of verification and assumptions.

Note: Insert your full logframe. If your logframe was changed since your Stage 2 application and was approved by a Change Request the newest approved version should be inserted here, otherwise insert the Stage 2 logframe.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Goal: Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources.			
Outcome: Improved capacity of Ethiopian farming communities, government agencies and other stakeholders to (a) identify and understand the harmful environmental effects of agrochemical use close to biodiversity-rich wetlands (b) develop and implement practical solutions based on agroecological farming and (c) align agricultural policies with biodiversity conservation goals. Farming communities around the Rift Valley Lakes will benefit from safer and sustainable pest management, better water quality and ecosystem services. Government agencies and conservation bodies will gain the skills to monitor pesticide impacts jointly with rural communities and feed robust evidence into policy forums	A. Desk officer and official support assigned by Arba Minch Plant Health Clinic to support project on biodiversity monitoring by year 2. B. Species richness in cotton cropping areas under IPM management increases by 50% compared to conventional plots by year 3 C. Dose rate of highly hazardous pesticides used on 500 hectares on two large cotton farms decreased 50% by Y3 D. Production costs of Members of organic and IPM crop farmers' cooperative (35 men and 5 women) are 750 Birr per hectare or less by year 3, compared to 2475 Birr per hectare by farmers relying on pesticides (baseline) E. Agricultural extension workers teaching IPM and food spray methods increases from 0% at baseline to 50% by year 3 (n = 48) F. At least 10 members of local communities are motivated to adopt new practices that protect or strengthen ecological processes and biodiversity, due to increased understanding of ecosystem services and the Ecosystem Approach, as demonstrated by testimonials	Project Agreement with AM PHC Photos of office space Participation of officer IPM field records (logbooks and excel versions) Large cotton farm records (Lucy and Amibara) FFS logbook – discussions held Conventional farmer records Farmer survey conducted at field open days Reports of discussions at village meetings and coop meetings Local extension services records promoting IPM (e.g. Agriculture promotion events, forestry dept) Change stories collected by students (practices may include vegetable farmers saving money in production costs by adopting IPM; establishing bat boxes or bird feeders; etc) Reports of Open Days & comm. events	Increased awareness of the value of biodiversity leads to action at local level Farmers are able to reduce use of pesticides by effectively applying IPM. Decreased pesticide use leads to biodiversity gains Large farms have accurate records of pesticide use at baseline PAN International HHP is recognized by farm managers as an authoritative source; and agree with results and evidence of IPM trials TRAID project produces production and marketing results that benefit farmers Willingness of farmers to join cooperative and affordability of membership fees IPM farmers willing and able to share experience with other farmers Very low baseline awareness of government can be overcome to enable individuals to make a link between agro-ecology approach and biodiversity conservation Low level of baseline awareness among relevant community members and students of ecosystem services

			and biodiversity
Outputs: **1**. National researchers are able to design, conduct, interpret and report on scientifically robust research on biodiversity and ecosystem impacts of agricultural systems	1a. The quality of ecotox monitoring field project developed by the Core Darwin Team , increases by Year 3 as demonstrated by at least 50% improvements in scores on written outputs, and by at least 30% in pre and post training assessments 1b. At least 10 local people (Local Monitoring Team, LMT, members) are able to conduct ecosystem services assessments by year 3 (from none at baseline), as documented by the completed species and ecosystem services surveying forms	Evidence of progression of quality of written outputs[1] from an average score of <3 in first drafts to an average score of >6, as indicated by the scoring matrix Pre and post-training assessments for at least 5 CDT members and Survey-monkey annual survey Participants lists in field data collection surveys (Local Monitoring Teams, LMT) Pre- and post-training assessments Improvement in quality of forms completed as demonstrated through participatory comparative assessments with LMT members after each field survey	High quality capacity building support has been effectively provided by NR Group to CDT Effective engagement and training of local people by CDT Access to students within the school environment; and interest and participation by students
2. Output 2. Monitoring data presents robust evidence of pesticide use and its impacts	2.1 Ziway reports on pesticide use, survey of residue levels entering and residing in the lake, and biological monitoring of lake's littoral ecosystem is published by year 3 2.2 Arba Minch report on pesticide use and impacts in different agricultural systems published by year 3, comparing the net impact of IPM and conventional cotton farmers on natural capital (including biodiversity) and ecosystem services	Biological monitoring and lab pesticide residue data, analysis and reports Collected data (logbooks for FFS and conventional farmers) analysis and publications of results Reports published	Data on pesticide use in flower farms is accessible Pesticide residue analysis feasible within budget There are cotton farmers in the area producing conventional cotton
3.. Knowledge of the relationship between agriculture, pesticide use, biodiversity and poverty is held by local government and communities.	3.1 At least 2000 cotton smallholder farmers participating in FFS and 2 plantation managers and 2 workers are able to identify beneficial insects and ecosystem services; and describe negative impacts of pesticides on ecosystem services by the end of the project 3.2 At least 50% of local community members surveyed at the end of local events (compared to less than 10% at pre-meeting surveys) can correctly describe the effects of pesticides on agro-ecosystems, and	Collected data (logbooks for FFS and conventional farmers) analysis and publications of results Reports published IPM baseline surveys conducted prior to all farmers beginning FFS Beneficial insects and other ecosystem services as identified by farmers records and compiled in FFS logbooks Awareness of negative impacts of	FFS are an effective mechanisms for sustainable farmer development Project actors are able to accurately explain concepts in locally appropriate ways

[1] e.g. Desk Assessment; Biological and chemical Monitoring Plans (AM & Z); Analysis: Reports

	the consequences of their own production choices on biodiversity and ecosystem services	pesticides as compiled in records of farmer discussion sessions by Field Agents Participant lists and records of discussions held Pre- and post-workshop surveys School Environment Clubs – after ES training Mini Media	
4. Knowledge and data are presented that seek to influence policy on pesticide use	4.1 At least seven Ethiopian and regional government, farmer, academic, private sector and conservation stakeholders recognize the validity of and cite the ecotox monitoring results in their own publications; and make public commitments to further actions to address the external costs of pesticide harm at three national workshops 4.2 At least 20 public officials or researchers working in other developing countries or at the international level make requests for information on the project results and methodologies; and at least 5 of these result in follow up meetings or exchanges of experience aiming at further adoption of the project approaches	Publications of stakeholders (e.g. NBSAP, action plans, NIP, AEWA Action Plan 6 on Education & Information etc) Meeting reports, transcripts and videos Follow up communications and development of joint activities on further actions (e.g. project proposals or MoUs) Email records; publications Distribution lists for communications materials Follow up communications and development of joint activities on further actions (e.g. project proposals or MoUs)	Policy environment is receptive to evidence Team have sufficient knowledge of policy environment to influence it Project results are relevant and applicable beyond the Ethiopian context of the project activities Project partners have access to international audiences

Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)

Activity 1.1 Desk Assessment

Activity 1.2 Incrop and outcrop monitoring plans.

Activity 1.3 Pesticide residue and biological monitoring protocols

Activity 1.4 Training and data collection by LMT in Arba Minch

Activity 2.1. Residue monitoring sampling and analysis (Ziway)

Activity 2.2. Biological monitoring training and data collection.(Ziway)

Activity 2.3 Data analysis and reporting (Ziway)

Activity 2.4 FFS data adapted and analysed for ecosystem services

Activity 2.5 Outcrop (bird and vegetation) monitoring and reporting

Activity 3.1 TRAID FFS training in Arba Minch & Farmer Field Day

Activity 3.2, School Environment Club member training and Ecosystem Service appreciation (Ziway)

Activity 3.3 Public meetings with members of spinning cooperatives, farmer cooperatives and tourism and agribusiness operators held

Activity 4.1. Develop communication plan for national and international outreach

Activity 4.2. Present Darwin project and results at national meetings and workshops on related topics.

Activity 4.3 Present Darwin project and results at international meetings

Activity 4.4 Follow up meetings and exchanges with interested researchers or partners

Annex 2 Report of progress and achievements against final project logframe for the life of the project

Note: For projects that commenced after 2012 the terminology used for the logframe was changed to reflect DFID's terminology.

Project summary	Measurable Indicators	Progress and Achievements in the last Financial Year ((2015-2016)
Outcome Improved capacity of Ethiopian farming communities, government agencies and other stakeholders to (a) identify and understand the harmful environmental effects of agrochemical use close to biodiversity-rich wetlands (b) develop and implement practical solutions based on agroecological farming and (c) align agricultural policies with biodiversity conservation goals. Farming communities around the Rift Valley Lakes will benefit from safer and sustainable pest management, better water quality and ecosystem services. Government agencies and conservation bodies will gain the skills to monitor pesticide impacts jointly with rural communities and feed robust evidence into policy forums.	A. Desk officer and official support assigned by Arba Minch Plant Health Clinic to support project on biodiversity monitoring by year 2.	2 officers from the Arba Minch Plant Health Clinic were assigned as members of the LMT. The project office in Arba Minch is hosted by the PHC. In year 3, the Ministry of Agriculture conducted an evaluation of PAN E programme in Arba Minch in support of a new joint programme to further support agroecological cotton production in the area. In both years 2 and 3, the top zonal politician (Mr Katene Kawale) opened the Farmer Field Days, showing support from local government from the woredas of Arba Minch Zuria and Merab Abaya.
	B. Species richness in cotton cropping areas under IPM management increases by 50% compared to conventional plots by year 3	Statistical treatment of results from plots in one of the two large cotton farms showed a significant impact on certain cotton pest natural enemies, reducing their abundance in comparison to untreated cotton, whilst having no effect on the cotton pests themselves (no reduction in pest numbers compared with untreated cotton)
	C. Dose rate of highly hazardous pesticides used on 500 hectares on two large cotton farms decreased 50% by Y3	5 HHP used in 2014 at the two farms (Amibara and Lucy) Amibara 2014: Carbosulfan –0.375Kg/ka ; Dicofol –0.37kg/ha; Endosulfan - 3.125kg/ha In 2015: Endosulfan-1.25kg/ha Lucy 2014: Endosulfan –2.5kg/ha * Chlorpyrifos – 1.5kg/ha * Dimethoate 2.4kg/ha. In 2015: Endosulfan- 2/5kg/ha. NB: amounts are active ingredients of the chemicals
		100% reduction in the small (0.25ha) demonstration plots
	D. Production costs of Members of organic and IPM crop farmers' cooperative (35 men and 5 women) are 750 Birr per hectare or less by year 3, compared to 2475 Birr per hectare by farmers relying on pesticides (baseline)	Data was collected for both IPM and conventional plots in 2014 but is not yet compiled. 20 smallholder farmers from Shelle Mella obtained a price for their 2014 seed cotton of 16 ETB, increased from 10 ETB in 2013 The coop obtained local credit up to $10,000 in 2015, built a storage site, sold certified seed, to increase their economic performance, and managed to break a previous monopoly of cotton middlemen and traders. They managed to get 33ETB for their A-graded lint cotton in 2015! They also sold their seed for edible oil refiners for $10, 470. They also sold the lint cotton for $35, 593.
	E. Agricultural extension workers teaching IPM and food spray methods increases from 0% at baseline to 50% by year 3 (n = 48)	There are 31 (23 men and 8 Women) agricultural extension agents who were involved in the IPM-FFS facilitation in 9 villages.
		In addition to the extension agents who are working at the grassroots level, agricultural experts from Zone (3 Men), two Woredas (9, 8 Men and 1 Woman), Arba Minch Plant Health Clinic (5, 4 Men and 1 Woman) and the two commercial farmers were involved in the cotton project i.e. Lucy (4 Men) and Amibara (3 Men) farms.
	F. At least 10 members of local communities are motivated to adopt new practices that protect or strengthen ecological	School environment club teachers continue field walks and bird ID (4 teachers) School club student perform dramas and poems on ecotox, environmental degradation and impact on people (137 students)

	processes and biodiversity, due to increased understanding of ecosystem services and the Ecosystem Approach, as demonstrated by testimonials	Parents have stopped storing pesticides at home, now wear PPE, and make compost for their crops Farmers recognize lacewings, ladybirds and hoverfly larvae but now recognize them as predators and have stopped spraying them with pesticides
Output 1. National researchers are able to design, conduct, interpret and report on scientifically robust research on biodiversity and ecosystem impacts of agricultural systems	1.1 The quality of ecotox monitoring field project developed by the Core Darwin Team , increases by Year 3 as demonstrated by at least 50% improvements in scores on written outputs, and by at least 30% in pre and post training assessments	Average score increase on key outputs (n= 6): 28%. The improvement is decreasing compared to Year 1, as initial versions are being submitted at a much higher standard. Average participant improvement in original partner training (August 2013): 40.5% (see Inception Training report for details).
	1.2 At least 10 local people (Local Monitoring Team, LMT, members) are able to conduct ecosystem services assessments by year 3 (from none at baseline), as documented by the completed species and ecosystem services surveying forms	7 LMT members (3 Field Agents and 3 local agriculture officers; 1 forestry agent in outcrop team. Training on biological monitoring Mar 2015 -2 teachers + 2 students from Batu High School (3M, 1F) Survey of LMT members Feb 2016
Activity 1.1 Desk Assessment		Completed
Activity 1.2 Incrop and outcrop monitoring plans.		Completed
Activity 1.3 Pesticide residue and biological monitoring protocols		Completed.
Activity 1.4 Training and data collection by LMT in Arba Minch		4 field monitoring visits: Oct 2014 – Jul 2015 – Sept 2015 – Feb 2016
Output 2. Monitoring data presents robust evidence of pesticide use and its impacts	2.1 Ziway reports on pesticide use, survey of residue levels entering and residing in the lake, and biological monitoring of lake's littoral ecosystem is published by year 3 2.2 Arba Minch report on pesticide use and impacts in different agricultural systems published by year 3, comparing the net impact of IPM and conventional cotton farmers on natural capital (including biodiversity) and ecosystem services	Completed, with both final reports published in Year 3.
Activity 2.1. Residue monitoring sampling and analysis (Ziway)		Completed. Reports (2): Residue monitoring protocol & Biological Monitoring Report
Activity 2.2. Biological monitoring training and data collection.(Ziway)		Completed. Field monitoring Mar 2015 (included training by NR expert) – May 2015 – Sept 2015 – Feb 2016.
Activity 2.3 Data analysis and reporting (Ziway)		Complete. Reports (2): Biological monitoring protocol & final report
Activity 2.4 FFS data adapted and analysed for ecosystem services		Complete. 2 large farms established plots in 2015 season; statistical analysis completed in 2016. Included in Arba Minch final report.
Activity 2.5 Outcrop (bird and vegetation) monitoring and reporting		Field monitoring conducted 4 times: Oct 2014 – Jul 2015 – Sept 2015 – Mar 2016. Reports (2): outcrop monitoring protocol & final report
Output 3. Knowledge of the relationship between agriculture, pesticide use, biodiversity and poverty is held by	3.1 At least 2000 cotton smallholder farmers participating in FFS and 2 plantation managers and 2 workers are able to identify beneficial insects and ecosystem services; and describe negative impacts of pesticides on ecosystem services by the end of the project	2014: 112 (11 female) farmers able to act a facilitators; a further 30 farmers were trained in 8 FFS sites. 224 participants at October 2014 Farmer Field Day (Shelle Mela); 46/ 163 invited farmers were women (28%) 3 season-long FFS completed (total number participants = 90 (2013) + 142 (2014) + 1765 (2015) = 1976)

local government and communities.		See 2014 TRAID Annual Report for evidence that they are able to identify beneficial insects. At the end of each growing season there were Farmer Field Days attended by (Oct 2013 = 113, 21 women, Oct 2014 =224 (Shelle Mela); 46/ 163 invited farmers were women (28%); Oct 2015 = 241, 27 women) 2013 Baseline survey of trained farmers, included in list of deliverables (Arba Minch) 2014/5 TRAID Annual Report for evidence of ability to identify beneficials & baseline surveys for trained & untrained farmers
	3.2 At least 50% of local community members surveyed at the end of local events (compared to less than 10% at pre-meeting surveys) can correctly describe the effects of pesticides on agro-ecosystems, and the consequences of their own production choices on biodiversity and ecosystem services	137 School Environment Club members in Ziway (Batu High School) have participated in Ecosystem Service walks and correctly identified ecosystem services 13 out of 15 women farmers/ members of spinning cooperatives surveyed during the spinning association meeting spelled the adverse impacts of pesticides 5 members of LMT were able to recall bird and vegetation species from one training to another (Oct 2014 to Jul 2015).
Activity 3.1 TRAID FFS training in Arba Minch & Farmer Field Day		Completed. 3 seasons of FFS and 3 Farmer Field Days held.
Activity 3.2, School Environment Club member training and Ecosystem Service appreciation (Ziway)		Training conducted by CDT in Dec 2014; with NRG in February 2014; walks held by school teachers thereafter. Consolidated Report (2015)
Activity 3.3 Public meetings with members of spinning cooperatives, farmer cooperatives and tourism and agribusiness operators held		Spinning association survey – 10 Oct 2015 Farmer Field Days (2013, 2014, 2015) Training of School Environment Clubs (Sept 2013; Feb 2014) and repeated walks (June, August, October 2015)
Output 4. Knowledge and data are presented that seek to influence policy on pesticide use	4.1 At least seven Ethiopian and regional government, farmer, academic, private sector and conservation stakeholders recognize the validity of and cite the ecotox monitoring results in their own publications; and make public commitments to further actions to address the external costs of pesticide harm at three national workshops	Impacts of agrochemicals on biodiversity presentation, Apr 10-12 2014 (Kaleb Hotel) January 2015 – Workshop on Water Quality Monitoring in the Rift Valley Feb 2015 policy workers workshop in Ziway attended by 42 participants from 22 institutions Public commitments were made by all participants to increase engagement with the project and use results. Consultation workshop on draft 'National Pest Management Support Service' strategy – Sept 2015 Joint evaluation of PAN Ethiopia programme (TRAID & Darwin) by the Ethiopian Ministry of Agriculture local office in Arba Minch
	4.2 At least 20 public officials or researchers working in other developing countries or at the international level make requests for information on the project results and methodologies; and at least 5 of these result in follow up meetings or exchanges of experience aiming at further adoption of the project approaches	Basel, Rotterdam and Stockholm CoPs in Geneva, May 2015 SAICM International Conference on Chemicals Management (ICCM4) in Geneva, September 2015 Helvetas Symposium on pesticide reduction in agriculture, Zurich, Sept 2015 Darwin Initiative projects experience sharing workshop for project managers, London, April 2016 Fellowship exchange May 2016 with Dr Parthib Basu, Univ. Calcutta Collaboration planning meeting with Dr Basu, Dr Barbara Smith and Dr Julia Wright, from Centre for Agroecology, Water & Resilience at Univ. Coventry, June 2016 IDH Dutch Government GEF Soaring Birds – PAN Ethiopia support and role when the project begins

		Horn of Africa collaboration with PAN E, resulting in joint survey in project areas in 2016
Activity 4.1. Develop communication plan for national and international outreach		Completed
Activity 4.2. Present Darwin project and results at national meetings and workshops on related topics.		Completed
Activity 4.3 Present Darwin project and results at international meetings		Completed
Activity 4.4 Follow up meetings and exchanges with interested researchers or partners		Completed

Annex 3 Standard Measures

Code	Description	Total	Nationality	Gender	Theme	Language	Comments
Training Measures							
2	Number of Masters qualifications obtained	1	Ethiopian	Male	Ecotox		
4d	Number of training weeks for postgraduate students	4	Ethiopian	Male	Ecotox	En	Ziway, 2015 & 16
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification(e.g., not categories 1-4 above)	5	Ethiopian	Male	Ecotox	En	LMT, A Minch
6a	Number of people receiving other forms of short-term education/training (e.g., not categories 1-5 above)	4	Ethiopian	Male	Ecotox	English	CDT, inception trg
6b	Number of training weeks not leading to formal qualification	2	Ethiopian	Male	Ecotox	English	
7	Number of types of training materials produced for use by host country(s) (describe training materials) Training reports & materials – 7 local trainings held (Annex 3, Ecotox capacity & impact report), plus inception training ES walks methodology & forms List of bird & vegetation species at Arba Minch	11					

Research Measures		Total	Nationality	Gender	Theme	Language	Comments
10	Number of formal documents produced to assist work related to species identification, classification and recording.	5				En	Field guides – birds & vegetation, food spray manual; ecosystem

							service walks
11b	Number of papers published or accepted for publication elsewhere	3	UK			En	Pesticide News – Aug 2016

Dissemination Measures		**Total**	**Nationality**	**Gender**	**Theme**	**Language**	**Comments**
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	1					Ziway 2015
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	7					See Output 4

Physical Measures		**Total**	**Comments**
20	Estimated value (£s) of physical assets handed over to host country(s)		
21	Number of permanent educational, training, research facilities or organisation established		
22	Number of permanent field plots established		Please describe

Financial Measures		**Total**	**Nationality**	**Gender**	**Theme**	**Language**	**Comments**
23	Value of additional resources raised from other sources (e.g., in addition to Darwin funding) for project work	£248,23					

Annex 4 Aichi Targets

	Aichi Target	Tick if applicable to your project
1	People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	YES
2	Biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	
3	Incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	
4	Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	YES
5	The rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	
6	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	
7	Areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	YES
8	Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	YES
9	Invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	
10	The multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	
11	At least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.	
12	The extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	
13	The genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	

14	Ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	
15	Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	
16	The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	
17	Each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	
18	The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	
19	Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	YES
20	The mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.	

Annex 5 Publications

Type *	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. contact address, website)
Report,	*Desk Assessment Belay, A. , Amera, T. & Amberber M., 2014	All Ethiopian		All M	PAN Ethiopia, Addis Ababa	PAN UK
Report	Ecotoxicological & biodiversity monitoring within and between different cotton agroecosystems and in comparison to semi-natural forest areas, Arba Minch, Southern Ethiopia, Atalo Belay & Tadesse Amera (Eds.), 2016	All Ethiopian				PAN UK
Report	Monitoring potential impacts of flower farm drainage into Lake Ziway, using aquatic invertebrates as bioindicators of water pollution: Biological Monitoring Report, Muhammed R (2016)	Ethiopian				PAN UK
Report	Pesticide residue status of Lake Ziway, Ethiopia: Littoral Zone adjoining the Sher Flower Farm, Final Report, Dr Tarekegn Berhanu, Feb 2016	Ethiopian				PAN UK
Report	*Awareness raising workshop on safe use and mitigation of pesticide negative impacts on Migratory Soaring Birds and biodiversity in the Central Rift Valley Ecosystem of Ethiopia Belay, A. 2015	Ethiopian		M	PAN Ethiopia, Addis Ababa	PAN UK
Project Note	Monitoring ecosystem impacts of pesticides and agriculture: Capacity & impact	Greek	UK	F	PAN UK, Brighton	PAN UK
Project Note	Darwin Output Note: Experiences with ecosystem services walks; NR Group/PAN UK Guidance Note: How to run an ecosystem services walk					
	Darwin Initiative articles summarizing the final reports from Arba Minch & Ziway: in production, for August edition of Pesticide News					

Annex 6 Darwin Contacts

Ref No	20-018
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