Submit by Monday 1 December 2014

DARWIN INITIATIVE APPLICATION FOR GRANT FOR ROUND 21: STAGE 2

Please read the Guidance Notes before completing this form. Where no word limits are given, the size of the box is a guide to the amount of information required.

Information to be extracted to the database is highlighted blue.

ELIGIBILITY

1. Name and address of organisation (NB: Notification of results will be by email to the Project Leader in Question 7)

Applicant Organisation Name:	Royal Botanic Gardens, Kew
Address:	Royal Botanic Gardens
City and Postcode:	Kew. TW9 3AB
Country:	UK
Email:	
Phone:	

2. Stage 1 reference and Project title

Ref 2701	**Title (max 10 words)** Harnessing agricultural ecosystem biodiversity for bean production and food security.

3. Project dates, and budget summary

Start date:		**End date:**		**Duration:**
Darwin request	**2015/16** £101,052	**2016/17** **£**96,984	**2017/18** **£**90,726	**Total request** £ 288,762

Proposed (confirmed and unconfirmed) matched funding as % of total Project cost:

Matched funding confirmed: £XXX
Matched funding unconfirmed*: £XXX
Kew salaries: £XXX
NRI salaries: £XXX
Total: £178,020

Are you applying for DFID or Defra funding? (Note you **cannot** apply for both)	**DFID**

4. Define the outcome of the project. This should be a repetition of Question 24, Outcome Statement.

(max 30 words)

Smallholder farmers implement science-based interventions for enhancing and restoring ecosystem services and biodiversity in East African agricultural systems, improving bean yield and quality, safeguarding food security and alleviating poverty.

5. Country(ies)

Which eligible host country(ies) will your project be working in. You may copy and paste this table if you need to provide details of more than four countries.

Country 1: Tanzania	**Country 2: Malawi**
Country 3:	**Country 4:**

6. Biodiversity Conventions

Which of the conventions supported by the Darwin Initiative will your project be supporting? Note: projects supporting more than one convention will not achieve a higher scoring

Convention On Biological Diversity (CBD)	**Yes**
Nagoya Protocol on Access and Benefit Sharing (ABS)	**No**
International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	**Yes**
Convention on International Trade in Endangered Species (CITES)	**No**

6b. Biodiversity Conventions

Please detail how your project will contribute to the objectives of the convention(s) your project is targeting. You may wish to refer to Articles or Programmes of Work here.
Note: No additional significance will be ascribed for projects that report contributions to more than one convention

(Max 200 words)

Project partner countries Tanzania and Malawi have ratified the CBD. This project supports CBD article 1 - conservation of biological diversity, sustainable use of its components and sharing of benefits arising out of use and article 6 - developing national conservation strategies and sustainable use of biological diversity into relevant programmes and policies. The project also contributes to bean production which is an ITPGRFA Annex 1 crop (*Phaseolus* beans). Agricultural ecosystem services will be improved through augmentation of pollinators and natural enemies of pests in bean production also addressing several Aihchi-2020 targets. Specifically the project will

a. raise awareness among farmers and government about how biodiversity underpins food security and how it can be conserved sustainably to improve bean production
b. incentivize maintenance and enhancement of ecosystem biodiversity supporting biorational pest management nationally and regionally.
c. improve bean yield and quality and ultimately food security, through enhanced biodiversity, and promoting sustainable use of pesticidal plant species.
d. integrate poverty reduction strategies based on enhanced biodiversity regionally
e. reduce the rate of loss and fragmentation of biodiversity in bean production systems relevant to 1.5 million ha.
f. develop sustainable landscape management interventions, ensuring conservation of the biodiversity that underpins food security and rural wealth

Is any liaison proposed with the CBD/ABS/ITPGRFA/CITES focal point in the host country?

☒ **Yes** ☐ **No** **if yes, please give details:**

Owing to the relevance of the project outputs to CBD we have established contact with CBD national focal points through NMAIST and LUANAR in Malawi and Tanzania. The current CBD national focal point in Tanzania is Mrs. Esther Shushu Makwaia, Principal Environmental Officer, Division of Environment and in Malawi is Dr. Aloysius Kamperewera Director, Environmental Affairs Department who have both been informed about this project and been invited to join an external advisory panel to evaluate relevance and progress of the action. We are also in communication with the Malawian ITPGRFA national focal point Lawrent L.M. Pungulani who is very supportive of the action (see accompanying correspondence). We have also notified Dr Fidelis Myaka, the National Focal Point in Tanzania for the ITPGRFA who also provided written support for the work.

7. Principals in project. Please identify and provide a one page CV for each of these named individuals. You may copy and paste this table if you need to provide details of more personnel or more than one project partner.

Details	Project Leader	Project Partner 1 - Main	Project Partner 2
Surname	**Prof Stevenson**	**Prof Ndakademi**	**Dr. Arnold**
Forename (s)	**Philip C**	**Patrick**	**Sarah E.J.**
Post held	**Professor/Senior Research Leader**	**Dep Vice Chancellor**	**Research Fellow**
Organisation (if different to above)		**Nelson Mandela African Institute for Science and Technology**	**Natural Resources Institute, University of Greenwich**
Department	**Natural Capital**	**Ecosystems and Biodiversity**	**Agriculture Health and Environment**
Telephone			
Email			

Details	Partner 3	Collaborator
Surname	**Kabambe**	**Gurr**
Forename (s)	**Vernon**	**Geoff M.**
Post held	**Professor.**	**Professor of Applied Ecology**
Organisation	**Lilongwe University of Agriculture and Natural Resources (LUANAR)**	**Charles Sturt University, Orange Australia**
Department	**Crop Science**	**Agricultural & Wine Sciences**
Telephone		
Email		

8. Has your organisation been awarded a Darwin Initiative award before (for the purposes of this question, being a partner does not count**)? If so, please provide details of the most recent awards (up to 6 examples).**

Reference No	Project Leader	Title
21-006	Kate Gold	Balancing conservation and livelihoods in the Chimanimani forest belt, Mozambique
21-005	Moctar Sacande	Pesticide plants for organic cotton, livelihoods and biodiversity in Mali
21-003	Hugh Pritchard	Protecting Ugandan endemic cycads from biodiversity loss and trafficking
20-021	William Milliken	Forest Futures: livelihoods and sustainable forest management in Bolivian Amazon
20-020	Stuart Cable	Madagascar Agroforestry Livelihoods Project

9a. If you answered 'NO' to Question 8 please complete Question 9a, b and c.
If you answered 'YES', please go to Question 10 (and delete the boxes for Q9a, 9b and 9c)

9b. DO NOT COMPLETE IF YOU ANSWERED 'YES' TO QUESTION 8.

Provide detail of 3 contracts previously held by your organisation that demonstrate your credibility as a research organisation and provide track record relevant to the project proposed. These contacts should have been held in the last 5 years and be of a similar size to the grant requested in your Darwin application.

9c. DO NOT COMPLETE IF YOU ANSWERED 'YES' TO QUESTION 8.

Describe briefly the aims, activities and achievements of your organisation. (Large organisation please note that this should describe your unit or department)

10. Please list all the partners involved (including the Lead Institution) and explain their roles and responsibilities in the project. Describe the extent of their involvement at all stages, including project development. This section should illustrate the capacity of partners to be involved in the project. Please provide written evidence of partnerships. Please copy/delete boxes for more or fewer partnerships.

Lead institution and website:	**Details (including roles and responsibilities and capacity to engage with the project): (max 200 words)**
Royal Botanic Gardens, Kew **www.kew.org**	The project will be managed by Kew, building upon current collaborations with NMAIST and NRI/University of Greenwich. Professor Stevenson, Project Leader, has 20 years experience developing environmentally benign technologies for improved food security in rural communities in sub-Saharan Africa that use plants sustainably and tackle challenges relating to availability and focus on poverty alleviation. Stevenson will contribute technically to project activities, while also managing and providing leadership. Kew will provide the technical expertise in plant sciences to the project. Specifically, Kew will conduct plant diversity surveys of bean agricultural ecosystems and the training. Dr Iain Darbyshire who has 15 years of experience surveying African plants will lead plant biodiversity surveys and training of NMAIST post grads to extend the project reach. Kew will evaluate of biological activities of pesticidal plants against field and storage pests. In summary Kew will: • Oversee the technical and financial management of the project • Ensure all activities are carried out to time and budget. • Chair six-monthly project steering group meetings • Implement the communication strategy for project outputs • Ensure timely reporting to the DI • Co-supervise the McKnight Foundation co-funded PhD student • Kew will lead M&E with a Tanzanian based socio-economic consultant Mrs Juliet Tembo.

Partner Name and website where available:	**Details (including roles and responsibilities and capacity to engage with the project): (max 200 words).**
Professor Patrick Ndakademi	**Role:** NM-AIST is a post graduate college for MSc and PhD by teaching and research. This project will provide opportunities for at least 10 MSc students to undertake research projects that contribute towards and are essential for their degrees under the stewardship of Prof Ndakademi. Biodiversity surveys for plants and invertebrates will be carried out by Kew and NRI with Charles Sturt University respectively alongside post grad students from NMAIST who will then continue to collect data across the research area and undertake experiments that specifically evaluate the suitability of plant species as habitat and forage for key invertebrate species. In addition all local logistics and field activities will be coordinated and managed by NM-AIST under the leadership of Prof Ndakademi. Research activities undertaken by NMAIST will support the current project and build capacity in Tanzanian environmental science community. Ensure timely reporting to the Kew management team**.** **Capacity to engage with project:** Prof Ndakademi is co-PI for a project developing protocols to safely use *pesticidal* plants in bean cropping systems to control pests. This experience and associated network of farmers will be built upon and expanded through this proposed action to understand the ecological role some of these plant species play in the bean ecosystems supporting beneficial insects and so identify dual purposes for key plant species that contribute to pest control.
Have you included a Letter of Support from this institution?	Yes

Partner Name and website where available:	**Details (including roles and responsibilities and capacity to engage with the project): (max 200 words)**
Dr SEJ Arnold Natural Resources Institute, University of Greenwich. **www.nri.org**	**Role:** NRI will lead the insect biodiversity survey, providing training in insect survey and identification techniques for local scientists and post graduate students in Tanzania and Malawi. NRI will also design monitoring and surveying strategies for gathering data on the baseline biodiversity on farms and the changes seen as a result of the management interventions proposed. NRI staff will conduct initial pollinator assessments to establish the most frequent and important pollinators of the crops in these systems. NRI will provide continuing remote support to entomologists on the ground in Tanzania and Malawi as the project proceeds. NRI will lead on the development and production of farmer relevant information bulletins on landscape management and augmentation of beneficial invertebrate biodiversity. Ensure timely reporting to the Kew management team**.** **Capacity to engage with project** Dr Arnold, the NRI lead, has 8 years' experience in pollinator-plant interactions and bee behaviour research and development, with particularly specialist knowledge in insect monitoring, pollination ecology and natural enemy ecology, with field and laboratory experience. She leads field activities on a current European Union project evaluating the biodiversity in Caribbean Cocoa plantations and has conducted field studies in Tanzania associated with tropical applied pollination and ecology projects.
Have you included a Letter of Support from this institution?	Yes

Partner Name and website where available:	**Details (including roles and responsibilities and capacity to engage with the project): (max 200 words)**
Vernon Kabambe. Professor of Crop Science LUANAR **http://www.bunda.luanar.mw/**	**Role:** LUANAR will lead implementation activities among 200 farmers in Malawi that adopt research outcomes from the biodiversity surveys and greenhouse studies of plant suitability. Mirroring those field actions undertaken in Tanzania these activities will determine the impact of specific ecosystem management interventions such as removal or augmentation of key field margin plant species on yield per plant, and per unit of land area. The impacts on poverty of specific interventions will be determined based on the overall improvements in quality of yield from baseline data that will be recorded at the outset of the project field activities. Impact evaluation will be carried out according to the methodology used in Tanzania and as designed by the M&E consultant. Ensure timely narrative and fiscal reporting to the Kew management team**.** **Capacity to engage with project:** Professor Kabambe has experience leading numerous agricultural development projects focussing on the evaluation of environmentally benign farmer participatory trials in Malawi and is currently Co-PI for a McKnight Foundation funded action on the pesticidal properties of field margin species for efficacy in controlling bean pests. Prof Kabambe also has experience at high level policy fora through which our project can influence agricultural strategy.
Have you included a Letter of Support from this institution?	Yes

Collaborator Name and website where available:	**Details (including roles and responsibilities and capacity to engage with the project): (max 200 words)**
Geoff Gurr, Professor of Applied Ecology, Charles Sturt University **http://www.csu.edu.au/faculty/science/saws/staff/profiles/academic-staff/geoff-gurr**	Professor Gurr will act as a collaborator providing leadership on methodologies relating to survey protocols for invertebrates, for advising on the development of laboratory and greenhouse bioassays to evaluate the effectiveness of key plants species at supporting the most important natural enemies and key pests species. These studies are important also to screen-out plant species that provide a benefit (e.g., nectar feeding) to pest species such as moths. He will advise on the most effective approaches to implementing interventions where bean ecosystems are engineered to augment key plant species to support natural enemies and pollinators and which can demonstrate effectively the impact of interventions. Prof Gurr will also be the primary supervisor for the proposed PhD student and will provide guidance for experimental projects for MSc student projects at NMAIST which will require visits to Tanzania to help build capacity in local students and personnel.
Have you included a Letter of Support from this institution?	Yes

11. Have you provided CVs for the senior team including the Project Leader	Yes

12. Problem the project is trying to address

Please describe the problem your project is trying to address. For example, what biodiversity and challenges will the project address? Why are they relevant, for whom? How did you identify these problems?

(Max 200 words)

Tanzania's national poverty reduction strategy paper highlights that food poverty exceeds 18% and agriculture is central to reducing this to 11% by 2015[1]. The step-change production increases required to achieve poverty reduction are realistic since yields of key crops such as beans (providing protein, micronutrients and vitamins in Tanzania and Malawi) are presently so low (500-700 kg/ha). Consequently, millions of farmers, particularly women (the primary bean growers in Malawi and Tanzania[2]) and their households, are at risk of nutritional deficiency and food insecurity[3]. Potential yields are >3000 kg/ha. Insects and the plant diseases they vector are the major biological constraint for beans[4]. Pesticides can control insects but are rarely used for reasons of economics and availability[5]. Biodiversity underpins agricultural ecosystem services and ultimately food security, livelihoods and economic development by augmenting natural enemies and reducing pest impacts[6], while bean yields are 40% lower without pollination[7]. Biodiversity in smallholder ecosystems, however, is poor in Tanzania and Malawi. Proposed biodiversity evaluations will identify plant species that support key beneficial invertebrates and enhance ecosystem service and resilience and enable farmers to grow beneficial plants within their cropping systems to improve food security and alleviate poverty.

13. Methodology

Describe the methods and approach you will use to achieve your intended outcomes and impact. Provide information on how you will undertake the work (materials and methods) and how you will manage the work (roles and responsibilities, project management tools etc.).

(Max 500 words – repeat from Stage 1 with changes highlighted)

This project will survey plant and invertebrate biodiversity in bean ecosystems in Tanzania and Malawi and evaluate their ecologies and identify plant species that (i) attract, nourish and provide habitat for natural enemies of pests; (ii) promote the activity of pollinator insects in crops and (iii) provide environmentally-benign 'botanical insecticides' as additional control for pests. This will require a systematic analysis of roles and interactions of pest and biological control species/habitats, supporting development of management systems that increase productivity through strategic integration of biodiversity. Using this knowledge we will develop interventions that maintain and optimise these ecosystem services.

1. Botanical and invertebrate biodiversity surveys of agricultural ecosystems will be conducted around bean farmland using transect methods, running parallel to field margins surveying 2 x 2 m plots every 10 metres to measure species occurrence/abundance in 25 locations evenly distributed across 4 agricultural zones based on altitude and rainfall. Associations between different habitats and species and between plants and beneficial insects

[1] http://www.imf.org/external/pubs/ft/scr/2011/cr1117.pdf

[2] http://www.researchintouse.com/nrk/RIUinfo/PF/CPP28.htm#L3

[3] Abate et al., 2012. . *Tropical Grain Legumes in Africa and South Asia: Knowledge and Opportunities.* PO Box 39063, Nairobi, Kenya: International Crops Research Institute for the Semi- Arid Tropics. 112 pp.

[4] Belmain et al. 2013. Managing legume pests in sub-Saharan Africa: Challenges and prospects for improving food security and nutrition through agroecological intensification. Chatham Maritime (United Kingdom): Natural Resources Institute, University of Greenwich. 34p

[5] Stevenson et al., 2014. Pesticidal Plants for stored product pest in small holder farming in Africa. In "Advances in Plant Biopesticides" Ed. D. Singh. Springer Verlag. pp 159

[6] Gurr et al. 2004 Ecological Engineering for Pest Management, CSIRO, Australia,

[7] Bartomeus et al., 2014 Contribution of insect pollinators to crop yield and quality varies with agricultural intensification. *PeerJ* 2:e328

including plants providing inter-seasonal refuge and habitat for pests, natural enemies and pollinators determined.
Levels of parasitism, crop damage and pest numbers correlated with plants and invertebrate diversity.
Local scientists trained in invertebrate and plant identification and collections based science.
Insectary and herbarium established at NMAIST to provide academic project legacy.
2. Plant evaluated for ability to support beneficial insects, providing novel research for proposed Africa based PhD student (registered at Charles Sturt University) and for MSc students at NM-AIST.
Survival and fecundity of beneficial insects on target species evaluated.
Farmer participatory field experiments, comparing different ecosystem assemblage, in 400 farm locations across two countries, will assess effects on plant species, natural enemy and pest numbers, predation and parasitism rates of pests, and infestation rate and crop damage in relation to insecticide spray thresholds.
3. Yields and quality of beans from bagged and non-bagged flowers will measure direct impact of pollinators in different ecosystems and determine associations between plant species biodiversity and pollination. Key plant species from secondary and tertiary ecosystems that contribute to habitat and supplement food for pollinators and which augment pollination services. We will evaluate how pollination services are affected by distance from stewarded margins.
4. Pesticidal plants evaluated for efficacy on key field and storage pests of beans e.g., *Helicoverpa armigera*, *Bemisia tabaci*, *Aphis fabae* and *Zabrotes* and *Acanthoscelides* spp. and impacts on four beneficial insects representing contrasting taxa and guilds.
5. Impact of enhanced biodiversity on bean production and poverty alleviation evaluated through surveys of 400 farmers in Tanzania and Malawi according to established measures, disaggregated for gender (Q27) and integrated into national and local development and poverty reduction policy through production of information leaflets in local languages, in high level policy briefs, field demonstrations and public outreach (TV, radio and newspapers).
6. Kew's project management experience will ensure efficient and transparent operation safeguarding timely progress of activities.
7. External advisory board comprising national focal points for ITPGRFA and CBD will provide critical commentary on project's progress and access to influence agricultural and environmental policy.

14. Change Expected

Detail what the expected changes this work will deliver. You should identify what will change and who will benefit.

- If you are applying for Defra funding this should specifically focus on the changes expected for biodiversity conservation and its sustainable use.
- If you are applying for DFID funding you should in addition refer to how the project will contribute to reducing poverty. Q19 provides more space for elaboration on this.

(Max 250 words)

Tanzania is the world's 7th largest bean producer, where millions of farmers – primarily women[8] – grow beans commercially and for home consumption. Beans are equally important in Malawi and currently 1.5 million ha are sown to beans across these countries providing critical protein source to millions of households. Predicted yield improvements based on earlier work[9] of ~20% could impact livelihoods cost effectively at household and national levels[10].

Biodiversity surveys of plant and invertebrate communities in bean ecosystems will facilitate targeted augmentation of natural enemies and pollinators thus improving Agricultural ecosystem services and directly addressing or providing evidence supporting CBD articles 1 and 6 and implementation of Aichi-2020 targets.

[8] http://www.researchintouse.com/nrk/RIUinfo/PF/CPP28.htm#L3

[9] Bartomeus et al., 2014. *PeerJ* 2:e328 and Amoabeng et al., 2013 *PLoS One*, 8(10): e78651,

[10] Amoabeng et al. 2014 *Crop Protection*. 57, 71-76

Tanzania and Malawi will have >20 scientists trained to conduct biodiversity surveys and develop reference collections and identification tools for use beyond the current project and in new cropping systems that could benefit from similar interventions.

Farmer demonstrations involving ~400 lead farmers in Tanzania and Malawi will incentivize maintenance / enhancement of ecosystem biodiversity by stakeholders and support bio-rational pest control options nationally and regionally and through associated activities will reach a further 3600 households directly and up to 200,000 households through outreach organisation NASFAM National Smallholder Farmers' Association of Malawi http://www.nasfam.org - a farmer-directed business system based on the individual participation of over 100,000 smallholders, farming on <1Ha land.

Policy briefs detailing the importance of biodiverse ecosystems and targeting Environment Departments, in Tanzania and Malawi, will be produced to lobby for policy development that enhances bean production nationally and regionally by maintaining and augmenting agricultural biodiversity.

15a. Is this a new initiative or a development of existing work (funded through any source)? Please give details (Max 200 words):

The proposed project is a unique approach to improving food security and alleviating poverty in African farming based on plant biodiversity in agricultural ecosystems that supports optimal diversity of pollinators and natural enemies. This will improve bean yield and quality and coincidentally identify plants that can be used in supplementary field and storage pest control. Interventions augmenting field margin plant species that support natural enemies have been implemented in rice by collaborator Prof Gurr, delivering measurable benefits in pest control[11]. Arnold and Stevenson are implementing an EU Caribbean project (FED/2012/290-490) augmenting Ceratapogonid midge pollinators (*Forcipomyia* spp.) of cocoa to enhance yields through increased pollination service that will inform this action while, Stevenson leads a project in East Africa (ACP S&T - FED/2013/329-272) optimising safe and effective use and access to botanical insecticides that will inform the project about species identified as supporting beneficial invertebrates to also provide additional pest control. However, the present Darwin proposal will be the first time these approaches to enhancing biodiversity for improved bean production and poverty alleviation will be implemented together and in any context in African agriculture and we anticipate the opportunity for Darwin funds to deliver a step change increase in bean yield (~20%) and quality.

15b. Are you aware of any other individuals/organisations/projects carrying out or applying for funding for similar work? ☒ **Yes** ☐ **No**

If yes, please give details explaining similarities and differences, and explaining how your work will be additional to this work and what attempts have been/will be made to co-operate with and learn lessons from such work for mutual benefits:

The evaluation of the potential for a bio diverse agricultural ecosystem to improve food security yield or quality has been studied in UK, Europe, Australia and East Asia but to our knowledge not before in Africa and nowhere combining both pollinator and beneficial invertebrate augmentation under a single strategy.

1. **Ecological Engineering in Rice Ecosystems**

Recent work by project collaborator Professor Geoff Gurr has shown that natural enemies of rice can be augmented by replacing the usual grassy weeds on bunds (the earth banks surrounding rice fields) with nectar plants that support key natural enemies but not moth pests.

[11] Zhongxian Lu et al. (2014) Rice Pest Management by Ecological Engineering: A Pioneering Attempt in China. In 'Rice Planthoppers: Ecology, Management, Socio Economics and Policy K.L. Heong · Jiaan Cheng · M.M. Escalada Editors, pp 163-180

Farmer participation ensures plants are agronomically suitable and have economic value (e.g., as seed crops). Attraction of wild and domesticated pollinator species is an additional ecosystem service that can accrue and of major importance to bean crops.

2. Impacts of pollinators in bean production in UK

Recent work in Europe has reported that Insect pollination enhanced average field bean yields up to 41%[12] by comparing bagged flowers to those allowed to be visited. Yield quality was also enhanced while the results indicated that biodiverse landscapes had a higher overall wild pollinator species richness, and visitation rates were higher in complex landscapes for some crops. Thus even in self-pollinated crops like beans pollination increases yields but it is not maximized under current agricultural intensification. African agriculture, however, relies heavily on wild pollinators which in turn are dependent on biodiverse plant assemblage.

3. Cocoa pollination optimization for increased cocoa yields and income generation (CocoaPOP)

An EU ACP S&T programme funded project which is led by the applicant. It seeks to build capacity in cocoa pollination research, and augment cocoa pollinators by enhancing pollinator habitats. The project demonstrates that augmenting pollinators is feasible while surveying techniques and farmers challenges will inform the current proposed action.

4. Optimising Pesticidal plants: Technology, Innovation, Outreach and Networks (OPTIONs).

ADAPPT (http://www.nri.org/projects/adappt) is an African research network of scientists and agricultural technicians established by the Lead Applicant under a European Union grant with a focus on environmentally benign pest management targeting poverty alleviation at the small-scale farming level, building strong scientific capacity in agriculture, biodiversity and conservation. The networks effectiveness was rewarded with follow on funding for OPTIONs to improve access to plant materials through propagation through cultivation in Kenya, Malawi, and Tanzania and will support the proposed action with resources and expertise – most notably through farmer networks for field trials in Tanzania and Malawi. These activities have demonstrated that field margin species are effective environmentally benign natural pesticides[13]

5. McKnight Foundation funded – Safer use of pesticidal plants.

A McKnight Foundation funded project via the Collaborative Crop Research Program and on which the applicant is a co-PI is developing safer ways to use plants as alternatives to pesticides in legume cropping in Tanzania and Malawi. The McKnight Foundation support current on-going activities at NMAIST and LUANAR and will contribute the fees to cover the costs of the PhD student.

Similarities of these actions to the proposed project:

- Augmentation of field margin species to avoid biodiversity loss and increase ecosystem resilience to deliver pollination services and support populations of natural enemies;
- Research supporting ecosystem enhancements to augment service delivery by pollinators and natural enemies.
- Consideration of plants as environmentally benign and safer alternatives pest control options.
- Enhancing institutional research capacity and incentive of the partners and so increase the quality and impact of research results and disseminated outputs and extent of the research impact;
- Targeting poverty eradication at the small-scale farming level; supporting development

[12] Bartomeus et al., 2014, *PeerJ* 2:e328

[13] Amoabeng et al., 2013 *PLoS One*, *8(10): e78651* Amoabeng et al. 2014 *Crop Protection*. 57, 71-76

and innovation in Africa (both).

Differences:

- The proposed project will investigate the scope for enhancing pollinator and natural enemy abundance and diversity in Tanzanian agricultural landscapes – an action that is unique in sub-Saharan Africa and never previously combining pollinator and other beneficial insect augmentation under a single strategy with pesticidal plants
- It aims to address farmers' needs through development research in order to increase income and reduce poverty via a strategy that simply relies on stewardship of field margins rather than time-consuming or costly interventions.
- The proposed project is focussed on ecosystem diversity to support natural enemies, pollinators and improve availability to plant resources that reduce the need to harvest species from the wild.
- The proposed project will train local scientists in biodiversity and ecological survey techniques and promote the importance of biodiversity in resilient and sustainable agriculture.
- The proposed project will raise awareness of the importance of field margins in delivering key ecosystems services and demonstrate how food security and poverty alleviation in African farming are dependent on biodiverse, resilient and healthy agricultural landscapes.

15c. Are you applying for funding relating to the proposed project from other sources?
☒ **Yes** ☐ **No**

If yes, please give brief details including when you expect to hear the result. Please ensure you include the figures requested in the spreadsheet as Unconfirmed funding**.**

Yes - we are applying to the McKnight Foundation Collaborative Crop Research Program for £75K to fund a PhD student to carry out empirical studies of natural enemy survival and development on key plant species that this project will identify as key species from field margins in bean production systems to determine the species most suited to support natural enemies and pollinators as well as those supporting pests.

The Director of the Research Programmes at McKnight Foundation (Professor Rebecca Nelson) has provided her support for this initiative and funding the student is likely although not entirely dependent on our success winning this grant. Applications for this funding will be submitted in January 2015 and a supporting letter from the Liaison Scientist for the McKnight Foundations Southern African Community of Practise accompanies this application.

The outcomes of the present project are not dependent on the support of the PhD student – however, the student will provide important new information that will increase the value and potential impact of the current proposed actions.

16. Value for money

Please describe why you consider your application to be good value for money including justification of why the measures you will adopt will secure value for money?

(Max 250 words)

Tanzania, one of the world's poorest countries, is ranked 159 out 186 in the Human Development Index (2013). Tanzania's national poverty reduction strategy paper highlights that agriculture is central to reducing food poverty[14]. Beans provide ~25% of the income for most farmers in Tanzania and Malawi so are a key component of poverty alleviation.

90% of beans are produced on small farms <2ha with annual household yields ~250kg of which half is sold and worth between 150 and 250USD. Through yield increases of 20% equivalent to 50USD per household per annum, this project will increase wealth to 400 participating farmers and a further 3600 via outreach, equal to increases in bean production worth 200,000USD per

[14] http://www.imf.org/external/pubs/ft/scr/2011/cr1117.pdf

annum.

Outreach activities including farmer field schools with distribution of information briefs in local languages will maximise this DI investment and ensure the project leaves a lasting legacy. By supporting small-scale bean production through strategies that enhance biodiversity in Tanzanian and Malawian agriculture the project will ensure that DI funding has a significant impact for poverty reduction, human welfare and conservation.

High-level capacity development of a PhD and 10 Master candidates to become leaders and change-agents, able to work on related projects and address other agricultural challenges. The advanced training in research skills, allied to joint publications in international journals and presentations at scientific conferences, will make the African scholars competitive for funding schemes to further their professional development in the EU and Australia e.g., the Australian Government's Endeavour Scheme[15].

17. Ethics

Outline your approach to meeting the Darwin Initiative's key principles for research ethics as outlined in the guidance notes.

(Max 300 words)

Kew's Policy on Access to Genetic Resources and Benefit Sharing which has been in place since 2001 (www.kew.org/conservation/index.html) means that ALL Kew staff operate in the full knowledge of the line and letter of the Convention of Biological Diversity.

All Kew staff travelling overseas for fieldwork surveys and botanical research must go through Kew's Overseas Fieldwork Committee to get permission to travel. This ensures that staff are aware of, and fulfil, requirement of CITES and CBD, including all national and local legislation on collecting and exporting genetic resources and associated traditional knowledge. This procedure also covers aspects relating to Health and Safety. Kew has developed peer reviewed guidance for staff on working with traditional knowledge and indigenous peoples so that staff are aware of the latest developments in this area. Kew has also developed a suite of standard model agreements, letters, prior informed clauses and documents for staff to use and develop with partner countries, partner institutions and with communities.

This project will take a participatory approach to Monitoring and Evaluation that is led by a specialist consultant (Julie Tembo, Dar Es Salaam) and use farmer surveys to gather feedback on the project's progress from the perspective of its beneficiaries. This will encourage ownership, leadership and participation from the communities directly involved in the project. Taking a transparent approach will also help ensure that the project team is held to account by the beneficiaries to deliver impact as detailed in this proposal.

Field trial methodologies will be submitted by NRI to the University of Greenwich ethics committee for approval to ensure they are designed and carried out ethically ensuring prior informed consent arrangements and health & safety of those involved in project are assured.

18. Legacy

Please describe what you expect will change as a result of this project with regards to biodiversity conservation/sustainable use and poverty alleviation (for DFID funded projects). For example, what will be the long term benefits (particularly for biodiversity and poor people) of the project in the host country or region and have you identified any potential problems to achieving these benefits?

(Max 300 words)

Bean production is a growth sector in Tanzanian and Malawian Poverty Reduction Strategy Papers but cultivation is threatening ecosystems. Making bean production more efficient and

[15] https://aei.gov.au/scholarships-and-fellowships/pages/default.aspx

benefiting more from those ecosystems will improve understanding of the importance of ecosystems for bean production and agriculture. This project will address poverty reduction and biodiversity conservation and support both countries CBD commitments.

The principal legacies will be

1. upscaling of research and field trial outcomes to 4000 farmers (400 directly participating in farmer trials - including at least 150 women farmers) and 3600 directly through networks and field schools and awareness raising among 100,000 NASFAM members.
2. a mind-set change about the importance of ecosystem stewardship and land management among farmers and agricultural technical staff – and in the longer term among policy makers through lobbying government departments and agencies through CBD and ITPGRFA National Focal Points in Malawi and Tanzania
3. Establish a plant and invertebrate reference collection at NMAIST along with specific information about the key species that are required to support pollinators and natural enemies of pests or pests themselves when crops are not available as food
4. Long term benefits – proven knowledge about the common and abundant species that are key to supporting beneficial insects in bean production
5. Farmers will be empowered in their own farm management by having increased appreciation for, and understanding of, the importance of biodiversity in crop production and distinguishing pest and beneficial insects
6. Approximately 20 scientists trained in survey techniques or field trials for ecological engineering to enable continuation of the work more widely and potentially on different crops.
7. Nationwide agricultural policies that encourage ecosystem health and the maintenance of biodiversity that support and enrich agricultural yields, ensuring greater food security and improved livelihoods for resource limited farmers.

19. Pathway to poverty alleviation

Please describe how your project will benefit poor people living in low-income countries. All projects funded through DFID in Round 21 must be compliant with the OECD Overseas Development Assistance criteria. Projects are therefore required to indicate how they will have a positive impact on poverty alleviation in low-income countries.

(Max 300 words)

Beans are Tanzania and Malawi's primary legumes are produced on 1,500,000 ha and consumed by >20 million people in Tanzania and Malawi. Yields are chronically low (<500kg/ha in Malawi) but are potentially ~3T/ha. Yet beans are a critical protein and mineral source for poor rural households and income to farmers, particularly women - the major growers of this crop. About 35% of the production in Malawi, for example, is marketed, contributing about 25% of total household income for over 68% of the households who sell surplus[16]. An increase in yield and quality of 20% could lead to a 5% overall increase in household income while increasing crop security and reducing food poverty.

Farmers typically sell their beans after harvest when prices are low. As well as supporting natural enemies of field pests some field margin plant species will be admixed to stored beans enabling longer-term storage of beans worth up to 2 times more when supplies later in the year are depleted.

This action will empower 400 farmers to benefit from their natural biodiversity and will secure their rights and drive pro-poor growth by encouraging exploitation of the multi-dimensional benefits of ecosystems services. Allied activities through the McKnight Foundation will ensure outreach to 3600 additional households using information bulletins and field schools illustrating how to implement proposed interventions and up to 100,000 families through NASFAM.

The proposed project is directly and primarily relevant to the problems of the target developing

[16] Kalyebara, 2005, *African Crop Science Conference Proceedings,* 7: 967-970

countries and therefore is compliant with the OECD Overseas Development Assistance criteria. The action will be undertaken with the promotion of the economic development and welfare of developing countries as its main objective and seeks to develop zero cost interventions that increase yield and crop quality so are well suited and relevant to current farming strategies in bean production.

19a. Impact to beneficiaries

If applying to DFID funding, please indicate the number of beneficiaries who are expected to be impacted by your project. If possible, indicate the number of women who will be impacted.

Direct beneficiaries will include 400 farmers (200 in each of Malawi and Tanzania) who will participate directly in DI funded field trials. Furthermore, this project will disseminate knowledge through provision of illustrated information bulletins to 3600 households in Malawi and Tanzania linking with the McKnight Foundation's project outreach service and farmer networks. Accompanied by field schools, these will explain using highly pictorial guides in local languages how to manage and conserve bean ecosystem biodiversity and how this will impact ecosystem service delivery and ultimately yield and quality of beans.

Post-graduate students (>10) studying on the Ecosystems and Biodiversity MSc at NMAIST and a PhD student will benefit from training in biodiversity survey techniques, plant and invertebrate identification, natural history collection establishment and maintenance and field trial design and impact evaluation.

The project will employ an M&E consultant Mrs Juliet Tumbo with experience in theory of change and development for poverty alleviation who will ensure that impacts can be measured meaningfully to provide a strong evidence for reporting to Darwin and producing briefs that will influence the agricultural and environmental policy agenda.

Beans provide about 25% of household income for over 68% of the households who sell surplus so improvements in yield will therefore directly impact wealth of target beneficiaries. An increase in yield and quality of 20% could lead to a 5% increase in household income while increasing crop security and reducing food poverty.

20. Exit strategy

State whether or not the project will reach a stable and sustainable end point. If the project is not discrete, but is part of a progressive approach, give details of the exit strategy and show how relevant activities will be continued to secure the benefits from the project. Where individuals receive advanced training, for example, what will happen should that individual leave?

(Max 200 words)

This project will build capacity and enable local partners and farming communities to become fully independent on all technical activities identified and developed for improved bean production.

Involvement of lead farmers in undertaking the field activities will enable the knowledge and experience gained to be disseminated through local extension community-based organisations to extend the outreach beyond the reach and lifetime of the project.

The agricultural communities' investment in the project (e.g. land and labour) will help ensure the ongoing maintenance of resilient ecosystems.

Outreach through NASFAM to 100,000 households and more still via TV and radio will maximise awareness raised throughout the target countries.

Regular dialogue and provision of policy briefings with Agricultural Departments in Malawi and Tanzania will encourage uptake of the actions developed into agricultural policy. This impact will be enhanced through associated actions where major activities are focussed on policy change (see OPTIONs project in Q15).

Well trained scientists will benefit from the knowledge gained about biodiversity surveys and the importance of resilient ecosystems into new ecosystems and biodiversity focussed careers.

Finally CBD and ITPGRFA national focal points will be provided with key information and materials with evidence that the bean systems support key ecosystem services on which bean production food security and nutrition rely and will be strengthened in their position to support and promote biodiversity for poverty alleviation.

21. Raising awareness of the potential worth of biodiversity

If your project contains an element of communications, knowledge sharing and/or dissemination please provide a description of your intended audience, how you intend to engage them, what the expected products/materials there will be and what you expect to achieve as a result. For example, are you expecting to directly influence policy in your host country or is your project a community advocacy project to support better management of biodiversity?

(Max 300 words) The communications, knowledge sharing and dissemination components of this project target subsistence bean producers and rely on a participatory approach to optimising the service delivery of bean ecosystems and will enable direct engagement and awareness raising among 400 farmers in Malawi and Tanzania.

Using the farmer networks for agricultural improvement through the McKnight Foundation in both countries will enable the project to outreach directly to an additional 3600 households growing beans in Malawi and Tanzania. 4000 information sheets providing farmer oriented guides to enhancing and benefitting from diverse ecosystems will be produced and distributed to all these potential beneficiaries and will provide illustrations and photographs to help farmers with species identification and technical comprehension.

Looking at wider influence, NASFAM has a membership of around 100,000 members and provides information services to 200,000 households through a monthly Newsletter and a weekly radio program in the region. We will inform farmers of the benefits of ecosystems management in legume production through this mechanism to reach non-project farmers.

The benefits of enhanced production through maintained or managed ecosystem biodiversity will be promoted through farming field school, exhibitions (video) and popular media including radio newspapers, and where possible, TV. Demonstration activities and wider communication activities will make use of local radio network, so as to ensure that those without literacy skills can participate and benefit fully.

The project will maintain dialogue with CBD and ITPGRFA focal points in Tanzania and Malawi (through NMAIST and LUANAR) *all of who have been invited to an external advisory board* and contribute international obligations regarding conservation of native species, raising awareness about the pressure on plant diversity and influence national policy about its conservation and more broadly the sustainable uses of plants.

22. Access to project information

Please describe the project's open access plan and detail any specific costs you are seeking from Darwin to fund this.

(Max 250 words)

Kew and its project partners recognise the importance of open access to publicly-funded research, datasets and technical reports. We will make all findings widely and freely available to maximise social and economic benefits and the impact of taxpayer money. Following the "Finch Report" on "Accessibility, sustainability, excellence: how to expand the access to research publications", and the government's response, Kew complies with open access recommendations.

We will make outputs available through the most appropriate, varied and effective dissemination formats. Primary research findings and associated datasets will be made available on a dedicated project website and published in open access peer reviewed research journals (3 papers are costed into the budget). At NRI accepted versions of all peer-reviewed articles are internationally available through its electronic archive within 90 days of acceptance. Datasets will also be published on new fora designed to maximise public availability of knowledge including researchgate.net.

Illustrated technical manuals aimed at farmers will be produced and distributed freely to provide key practical information that enable finding to be implemented by farmers outside the reach of the current action. These will be produced in local languages where appropriate and uploaded through NRI's publication website, making them internationally available.
We will use all available mechanisms to inform the public in the UK and in East Africa through press offices about the work and endeavour to draw attention to this work and Darwin Initiative through TV, radio and papers media as well as through ICT media including setting up a twitter and Facebook accounts.

23. Importance of subject focus for this project

If your project is working on an area of biodiversity or biodiversity-development linkages that has had limited attention (both in the Darwin Initiative portfolio and in conservation in general) please give details.

(Max 250 words)

There is strong evidence that ecosystem services, including biological pest control and crop pollination, benefit food production[17]. Biologically diverse agricultural ecosystems are healthier and resilient and more likely to enhance crop production through service provision and so underpin food security in smallholder farming. However, basic information on levels of diversity necessary to support beneficial invertebrates, and which are key plant species habitats for key pollinators and natural enemies is not known. Furthermore the level of pollinator contribution to yield and quality and impact of natural enemies is absent for almost all crops in Africa including beans. Recent evidence from Europe indicates pollinators play a major role in yield (40% increase) and quality in beans[18] which are otherwise largely assumed to be self pollinated, while ecological engineering of field margins augments natural enemies and improves food production in rice cropping systems in Asia[19]. Given that habitat loss and agricultural intensification are known to decrease invertebrate richness and abundance, the consequences of these important ecosystem services and their diversity for crop production needs to be assessed and understood to ensure benefit in low input crops are maximised.

While many field margin plants are crucial in providing habitat, refuge and forage for invertebrates beneficial to crop production – e.g. nectar and pollen for parasitic wasps and bees, especially outside cropping seasons, and habitat for spiders and carnivorous beetles - many of these plant species such as *Ageratrum conyzoides* also have pesticidal properties that can be exploited for pest management[20].

24. Leverage

a) Secured

Provide details of all funding successfully levered (and identified in the Budget) towards the costs of the project, including any income from other public bodies, private sponsorship, donations, trusts, fees or trading activity.

Confirmed:

NRI and Kew staff costs are fully over headed at 100% but have been charged to Darwin in the budget at only 40%. The remaining costs are being contributed by NRI and Kew respectively for the inputs of these staff.

Professor Geoff Gurr will contribute 10% of his time to the project but this cost will be entirely covered by Charles Sturt University at £XXXX/annum.

Professor Steve Belmain (NRI) will contribute 5% of his time to the project through NRI funds at £XXXX/annum.

[17] Bommarco et al., 2013, *Trends in Ecology and Evolution*. 28, 230-238
[18] Bartomeus et al., 2014 *PeerJ* 2:e328
[19] Zhu et al., 2014, *PLoS One:* 9: e108669
[20] Stevenson et al., 2014. Pesticidal Plants for stored product pest in small holder farming in Africa. In "Advances in Plant Biopesticides" Ed. D. Singh. Springer Verlag. pp 159 & Amoabeng et al., 2014 *PLoS One. 8(10): e78651*

b) Unsecured

Provide details of any matched funding where an application has been submitted, or that you intend applying for during the course of the project. This could include matched funding from the private sector, charitable organisations or other public sector schemes.

Date applied for	Donor organisation	Amount	Comments
Dec 2014	McKnight Foundation Southern African Community of Practise	75K	See accompanying letter of support from McKnight Liaison scientist.

PROJECT MONITORING AND EVALUATION

MEASURING IMPACT

25. LOGICAL FRAMEWORK

Darwin projects will be required to report against their progress towards their expected outputs and outcomes if funded. This section sets out the expected outputs and outcomes of your project, how you expect to measure progress against these and how we can verify this.

The information provided here will be transposed into a logframe should your project be successful in gaining funding from the Darwin Initiative. The use of the logframe is sometimes described in terms of the Logical Framework Approach, which is about applying clear, logical thought when seeking to tackle the complex and ever-changing challenges of poverty and need. In other words, it is about sensible planning.

Impact

The Impact is not intended to be achieved solely by the project. This is a higher-level situation that the project will contribute towards achieving. All Darwin projects are expected to contribute to poverty alleviation and sustainable use of biodiversity and its products.

(Max 30 words)

The harnessing of agricultural biodiversity in bean production systems of East Africa established and implemented widely to improve food security, reduce poverty and increase ecosystem resilience.

Outcome

There can only be one Outcome for the project. The Outcome should identify what will change, and who will benefit. The Outcome should refer to how the project will contribute to reducing poverty and contribute to the sustainable use/conservation of biodiversity and its products. This should be a summary statement derived from the answer given to question 14.

(Max 30 words)

Smallholder farmers implement science-based methods for enhancing and restoring ecosystem services and biodiversity in agricultural systems that improve bean yield and quality, food security and rural livelihoods.

Measuring outcomes - indicators

Provide detail of what you will measure to assess your progress towards achieving this outcome. You should also be able to state what the change you expect to achieve as a result of this project i.e. the difference between the existing state and the expected end state. You may require multiple indicators to measure the outcome – if you have more than 3 indicators please just insert a row(s).

Indicator 1	Roles and interactions of key plant and beneficial invertebrate species of agricultural ecosystems understood by farmers and agricultural technicians by end of project.
Indicator 2	Management methodologies that maintain ecosystem services and augment natural pest enemies and pollinators developed and implemented to increase yields by 20% from baseline data at project outset without additional agricultural inputs.
Indicator 3	Bean crop productivity and quality improved and monetary value of beans increased for 400 farmers by 20% by project end
Indicator 4	Role of agricultural biodiversity in crop quality, enhanced yield and consequent poverty alleviating benefits demonstrated to key stakeholders through participatory field trials.
Indicator 5	Yield and poverty impacts of enhanced biodiversity demonstrated through individual farmer surveys for bean production at project outset and project end that indicate increased income of 5-10% per household

Verifying outcomes

Identify the source material the Darwin Initiative (and you) can use to verify the indicators provided. These are generally recorded details such as publications, surveys, project notes, reports, tapes, videos etc.

Indicator 1	Biodiversity survey data and ecological interactions published in high impact peer reviewed journals and policy briefs.
Indicator 2	Ecological interventions that augment or maintain biodiversity implemented by stakeholders and adopted into policy (policy briefs, publications and radio/TV programmes) via CBD and ITPGRFA national focal points and established relationships between African project partners and Department of Agriculture.
Indicator 3	Data from farmers' surveys demonstrating how maintained and enhanced agricultural biodiversity improves bean yields and quality published.
Indicator 4	Educational materials produced and available (1) to enable Tanzania scientists trained during this project to carry on similar work after project end (reference collections and identification tools) and (2) to distribute widely to farmers and other stakeholders about how to maintain and enhance biodiversity (4000 local language information sheets).
Indicator 5	Yield and poverty impacts of enhanced biodiversity farmer surveys undertaken and results published reporting wealth increase from project outset to project end.

Outcome risks and important assumptions

You will need to define the important assumptions, which are critical to the realisation of the *outcome and impact* of the project. It is important at this stage to ensure that these assumptions can be monitored since if these assumptions change, it may prevent you from achieving your expected outcome. If there are more than 3 assumptions please insert a row(s).

Assumption 1	Farmers will adopt interventions that enhance the delivery of ecosystems

	service. Mitigation: Efforts will be made to provide as much information in local languages where necessary to ensure farmers are fully informed of the interventions proposed and the benefits.
Assumption 2	Findings will be taken up by agricultural policy makers. Mitigation: Policy briefs will be produced that highlight how maintained or enhanced ecosystems can improve productivity in bean production and address MKUKUTA II goals.
Assumption 3	Extreme weather conditions will not affect biodiversity sampling, particularly invertebrates. Mitigation: Sampling will be undertaken across three seasons to ensure that extreme weather events will not affect all data collection.

Outputs

Outputs are the specific, direct deliverables of the project. These will provide the conditions necessary to achieve the Outcome. The logic of the chain from Output to Outcome therefore needs to be clear. If you have more than 3 outputs insert a row(s). It is advised to have less than 6 outputs since this level of detail can be provided at the activity level.

Output 1	Ecosystems and plant species that are habitats for key natural enemies of bean pests identified.
Output 2	Key invertebrate pollinators of beans and their key habitat (plants/ecosystems) established at 25 locations in 4 agro-ecological zones.
Output 3	Capacity of 400 lead farmers increased by information and guidance on exploiting and maintaining agricultural biodiversity for improved crop yield.
Output 4	Field margin plant species that support beneficial insects evaluated for their biological activity against pest insect species of beans and negative effects on natural enemies and pollinators determined.
Output 5	Post-graduates trained in conducting biodiversity surveys and carrying out field and laboratory based research.

Measuring outputs

Provide detail of what you will measure to assess your progress towards achieving these outputs. You should also be able to state what the change you expect to achieve as a result of this project i.e. the difference between the existing state and the expected end state. You may require multiple indicators to measure each output – if you have more than 3 indicators please just insert a row(s).

Output 1	
Indicator 1.1	Plant biodiversity surveys undertaken across 25 farm locations in Arusha and Moshi by year 2
Indicator 1.2	Insect diversity surveys undertaken 25 farm locations in Northern Tanzania by year 2
Indicator 1.3	Associations between habitat type and plant of invertebrate species diversity established by end of year 2.

Indicator 1.4	Plant species of importance to beneficial insects and with pesticidal properties identified

Output 2	
Indicator 2.1	5 most important/abundant natural enemies of bean pests and their most important plant species habitats identified and target pest species determined by start of year 3.
Indicator 2.2	5 key/abundant pollinators of beans and their most important non-crop species habitats identified by start of year 3.
Indicator 2.3	5 most important pests identified and their most important non-crop habitats established through abundance, perceived impact and literature.
Indicator 2.4	Habitat quality index developed to assess relative risk and provisioning in habitat for supporting beneficial invertebrates

Output 3	
Indicator 3.1	Impact of field margin variation across bean production systems or ecological interventions on populations of natural enemies, pollinators and pest insects determined in year 1.
Indicator 3.2	Baseline evaluation of productivity and bean quality of 400 farmers in Malawi and Tanzania determined by end of year 1.
Indicator 3.3	Field trials conducted to determine impact of field margin variation across bean production systems on bean yields and bean quality in year 2.
Indicator 3.4	Impact of pollinators on bean yield and quality evaluated as a percentage improvement for each ecosystem and across the whole experimental area.
Indicator 3.5	Impact of changes in field bean ecosystem biodiversity on livelihoods evaluated through post field trial surveys, monitoring benefits to farmers' livelihoods including effects on financial wealth, nutrition and health.
Indicator 3.6	Impact of ecosystems on bean production disseminated to 3600 farmers through fields school and provision of information leaflets

Output 4	
Indicator 4.1	5 Plant species of potential importance as habitat and refuge for beneficial insects and with potential pesticidal properties identified.
Indicator 4.2	Plant species of potential value as pesticidal evaluated in laboratory and screen-house trials for efficacy against pests and effects against two key natural enemies determined by end of year 2.
Indicator 4.3	Pesticidal efficacy of plants evaluated in laboratory and screen-house against two key natural enemies.
Indicator 4.4	Farmer field trials evaluating efficacy of pesticidal plants to control bean pests and effects against key natural enemies and pollinators by end of year 3.
Indicator 4.5	Potential of pesticidal plants to increase production and bean quality evaluated through impact assessments in year 3

Output 5	
Indicator 5.1	At least 10 post graduate students trained and provided field experience in conducting botanical biodiversity surveys by end of project
Indicator 5.2	At least 10 post graduate students trained and provided field experience in conducting invertebrate surveys biodiversity surveys by end of project
Indicator 5.3	One PhD student provided training in laboratory and field evaluation of suitability of at least two plant species and two key beneficial insects by end of year 3

Verifying outputs

Identify the source material the Darwin Initiative (and you) can use to verify the indicators provided. These are generally recorded details such as publications, surveys, project notes, reports, tapes, videos etc.

Output 1	
Indicator 1.1	Research paper published in international refereed journals reporting plant and insect biodiversity surveys and associations between habitat type and plant of invertebrate species diversity
Indicator 1.2	See 1.1
Indicator 1.3	See 1.1
Indicator 1.4	See 1.1

Output 2	
Indicator 2.1	Research paper published in international refereed journals indicating most important invertebrates and their most important plant species habitats.
Indicator 2.2	See 2.1
Indicator 2.3	See 2.1
Indicator 2.4	Habitat quality index used to quantity diversity and incorporated in paper indicated in 2.1 as methods component

Output 3	
Indicator 3.1	Project report showing impact of field margin species variation on bean production. Website produced to provide global reporting vehicle and networking tool.
Indicator 3.2	Project report evaluating baseline productivity and bean quality of farmers in Malawi and Tanzania determined by end of year 1 – farmers survey reports.
Indicator 3.3	Project report of Field trials conducted to determine impact of field margin variation on bean yields and bean quality – farmer survey reports.
Indicator 3.4	Research paper reporting Impact of invertebrates on bean yield and quality evaluated as a percentage improvement across experimental area.
Indicator 3.5	Impacts on wealth, nutrition and health incorporated in to paper in 3.4.
Indicator 3.6	Production of 4000 information leaflets on the role of ecosystems in bean production.

	Policy briefs produced for high level audience. Radio interview and Newspaper stories.

Output 4	
Indicator 4.1	Research paper in international journal published reporting results.
Indicator 4.2	See 4.1
Indicator 4.3	See 4.1
Indicator 4.4	Farmer field trials evaluating efficacy of pesticidal plants to control bean pests and effects against key natural enemies and pollinators by end of year 3.
Indicator 4.5	Impact of pesticidal plants technologies to increase production and bean quality evaluated through impact assessments in year 3

Output 5	
Indicator 5.1	Graduate theses produced and research papers published by students reporting results.
Indicator 5.2	See 5.1
Indicator 5.3	PhD thesis produced and

Output risks and important assumptions

You will need to define the important assumptions, which are critical to the realisation of the achievement of your outputs. It is important at this stage to ensure that these assumptions can be monitored since if these assumptions change, it may prevent you from achieving your expected outcome. If there are more than 3 assumptions please insert a row(s).

Assumption 1	Bean ecosystems at least in some locations provide adequate diversity (i.e. have not already been degraded) to prevent meaningful biodiversity assessments in adequate locations. Mitigation: During the IPM workshop funded my McKnight earlier in 2014 from which this project idea arose – the participants visited two field locations to make a pilot assessment. This suggested that at least in two ecological zones in our target area that plant species showed some diversity and both natural enemies and pollinators occurred in measurable numbers to enable a meaningful evaluation of biodiversity across the region.
Assumption 2	Extreme weather conditions will not affect biodiversity sampling. Mitigation: Sampling will be undertaken across three seasons and at different times of the year – both during the cropping period and outside the cropping period to ensure that extreme weather events will not affect all data collection
Assumption 3	Farmers commissioned to undertake independent field activities that evaluate various technologies that arise from biodiversity surveys conduct those evaluations effectively and without resorting to the use of pesticides. Mitigation: At the outset of farmer trials and during the course of the cropping season farmers will be visited regularly to encourage and enforce the specific requirements for those field trials. Farmers will be provided clear guidance on how to conduct field trials.

Activities

Define the tasks to be undertaken by the research team to produce the outputs. Activities should be designed in a way that their completion should be sufficient and indicators should not be necessary. Risks and assumptions should also be taken into account during project design.

Output 1	
Activity 1.1	Plant surveys to determine botanical biodiversity across 3 ecological zones undertaken across 25 farm locations in Arusha and Moshi.
Activity 1.2	Invertebrate surveys to determine biodiversity among pollinators, natural enemies and pests across 4 ecological zones and undertaken across 25 farm locations in Arusha and Moshi, N. Tanzania.
Activity 1.3	Plant species occurrence and agroecosystem type correlated to establish key species in different locations.

Output 2	
Activity 2.1	Natural enemies of bean pests will be identified across experimental locations and the most important plant species identified and suitability of key plants species as habitat/refuge determined in laboratory and glass house experiments
Activity 2.2	Target pest species determined and likely natural enemies will be evaluated.
Activity 2.3	Insect surveys will be undertaken to identify the main pollinators of beans and through literature and field studies the most important plant species habitats determined across seasons to identify likely habitat outside the growing seasons.
Activity 2.4	Key pests species are already known for beans in East Africa so this activity will identify which plant species provide field margin refuge and habitat for all life stages of key bean pests e.g. for adults of Lepidoptera where their larvae are key pests.

Output 3	
Activity 3.1	Baseline evaluation of productivity and bean quality of 400 farmers in Malawi and Tanzania determined
Activity 3.2	Baseline field survey of the variation across bean production systems or ecological interventions on populations of natural enemies, pollinators and pest insects.
Activity 3.3	Field trials will be carried out in Malawi and Tanzania (200 farmers in each country) that will evaluate how specific field margin plant and natural enemy invertebrate species contribute to improved bean yields and bean quality.
Activity 3.4	Impact of pollinators on bean yield and quality evaluated will be evaluated through target field trials comparing bagged versus unbagged species and across locations to compare the absolute impact of pollinators sand the relative service delivery of pollination across different locations that differ in their plant and invertebrate diversity.
Activity 3.5	Impact of changes in field bean ecosystem biodiversity on livelihoods will be evaluated through post field trial surveys that compare production and quality at field locations and monitor absolute changes to farmers' livelihoods including increases in income, nutrition and health.

Activity 3.6	Production and dissemination of information leaflets to 3600 households.

Output 4	
Activity 4.1	During surveys species that are known through associated actions (See Q 15) field margin plant species of potential importance as habitat and refuge for beneficial insects but that also have pesticidal properties will be identified.
Activity 4.2	Pesticidal plants evaluated in laboratory and screen-house trials for efficacy against 3 pest species determined
Activity 4.3	Pesticidal efficacy of plants from Activity 4.2 will be evaluated in laboratory and screen-house against two key natural enemies.
Activity 4.4	Farmers in Tanzania and Malawi will be provided protocols to pesticidal plants to control bean pests and effects against key natural enemies and pollinators.
Activity 4.5	Impact of pesticidal plants technologies to increases production and bean quality evaluated through impact assessments

Output 5	
Activity 5.1	All plant diversity surveys will be undertaken as field trips for post graduate students on the Biodiversity and Ecosystems MSc at NMAIST providing training for 10 students in field collection in identification techniques as well as collection establishment.
Activity 5.2	Invertebrate diversity surveys will be undertaken as field trips for post graduate students on the Biodiversity and Ecosystems MSc at NMAIST providing training for up to 10 students in field collection techniques and identification and naming while a digital record of all taxa collected will be made.
Activity 5.3	A PhD student will be supervised to undertake training in specific laboratory and field evaluation of plants that determine the suitability of at least two plant species and two key beneficial insects that could be targets for ecological interventions. It is expected that this work will lead to information that identifies potential targets for propagation and distribution among bean farmers as a key environmentally benign input to improve production.

26. Provide a project implementation timetable that shows the key milestones in project activities. Complete the following table as appropriate to describe the intended workplan for your project.

	Activity	No of Months	Year 1				Year 2				Year 3			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Output 1														
1.1	Plant surveys to determine botanical biodiversity across 3 ecological zones undertaken across 25 farm locations in Arusha and Moshi.	4												
1.2	Invertebrate surveys to determine biodiversity among pollinators, natural enemies and pests across 3 ecological zones and undertaken across 25 farm locations in Arusha and Moshi.	4												
1.3	Plant species occurrence and agroecosystem type correlated to establish key species in different locations.	3												
Output 2														
2.1	Natural enemies of bean pests will be identified across experimental locations and the most important plant species identified and suitability of key plants species as habitat/refuge determined in laboratory and glass house experiments	3												
2.2	Target pest species determined and likely natural enemies will be evaluated.	1												
2.3	Insect surveys will be undertaken to identify the main pollinators of beans and through literature and field studies the most important plant species habitats determined across seasons to identify likely habitat outside the growing seasons.	3												
2.4	Key pests species are already known for beans in East Africa so this activity will identify which plant species provide field margin refuge and habitat for all life stages of key bean pests e.g. for adults of Lepidoptera where the larvae are and the key pests.	2												
Output 3														
3.1	Baseline evaluation of productivity and bean quality of 400 farmers in Malawi and Tanzania determined	2												
3.2	Baseline field survey of the variation across bean production systems or ecological interventions on populations of natural	2												

	enemies, pollinators and pest insects.													
3.3	Field trials will be carried out in Malawi and Tanzania (200 farmers in each country) that will evaluate how specific field margin plant and natural enemy invertebrate species contribute to improved bean yields and bean quality.	6												
3.4	Impact of pollinators on bean yield and quality evaluated will be evaluated through target field trials comparing bagged versus unbagged species and across locations to compare the absolute impact of pollinators sand the relative service delivery of pollination across different locations that differ in their plant and invertebrate diversity.	2												
3.5	Impact of changes in field bean ecosystem biodiversity on livelihoods will be evaluated through post field trial surveys that compare production and quality at field locations and monitor absolute changes to farmers' livelihoods including increases in income, nutrition and health.	2												
3.6	Production and dissemination of information leaflets to 3600 households.	1												
Output 4														
4.1	During surveys species that are known through associated actions (See Q 15) field margin plant species of potential importance as habitat and refuge for beneficial insects but that also have pesticidal properties will be identified	4												
4.2	Pesticidal plants evaluated in laboratory and screen-house trials for efficacy against 3 pest species determined	4												
4.3	Pesticidal efficacy of plants from Activity 4.2 will be evaluated in laboratory and screen-house against two key natural enemies	6												
4.4	Farmers in Tanzania and Malawi will be provided protocols to pesticidal plants to control bean pests and tritophic effects against key natural enemies and pollinators	12												
4.5	Impact of pesticidal plants technologies to increases production and bean quality evaluated through impact assessments	4												
Output 5														
5.1	All plant diversity surveys will be undertaken as field trips for post graduate students on the Biodiversity and Ecosystems MSc at	12												

	NMAIST providing training for 10 students in field collection in identification techniques as well as collection establishment													
5.2	Invertebrate diversity surveys will be undertaken as field trips for post graduate students on the Biodiversity and Ecosystems MSc at NMAIST providing training for up to 10 students in field collection techniques and identification and naming while a digital record of all taxa collected will be made.	12												
5.3	A PhD student will be supervised to undertake training in specific laboratory and field evaluation of plants that determine the suitability of at least two plant species and two key beneficial insects that could be targets for ecological interventions. It is expected that this work will lead to information that identifies potential targets for propagation and distribution among bean farmers as a key environmentally benign input to improve production.	36												
5.4														

27. Project based monitoring and evaluation (M&E)

Describe, referring to the Indicators above, how the progress of the project will be monitored and evaluated, making reference to who is responsible for the projects M&E. Darwin Initiative projects are expected to be adaptive and you should detail how the monitoring and evaluation will feed into the delivery of the project including its management. M&E is expected to be built into the project and not an 'add' on. It is as important to measure for negative impacts as it is for positive impact.

(Max 500 words)

M & E

Data for the first outcome indicators will be obtained at baseline and after each bean harvest. This data will be collected by the trained students who will administer a questionnaire within the targeted households. In the questionnaire the main questions which will be answered include: if the farmers have adopted and are implementing science based methods for enhancing and restoring ecosystem services and bio-diversity in agricultural systems; how many kilograms of beans a farmer yields per acre; income which a farmer earns from selling one kilogram of beans during the month of bean harvesting, and; Middle Upper Arm Circumference (MUAC) nutritional status for at least one child aged under five in 100 targeted farmer households. Data on the quality of beans produced will be obtained by taking a sample of harvested beans and checking it for weight and other quality indicators.

The outcome indicator data will also be compared to the national population based surveys, nutritional and agricultural surveys. Where relevant this data will be disaggregated by male and female. It is hoped that there will be a comparison of trends which show increases in adoption of science-based habitat management; bean yield; income from sales; nutritional status, and; bean quality. These trends will be used to justify the success and need to replicate the agricultural methods applied by the famers as a way of contributing towards national economic growth and poverty reduction strategies as well as health and welfare of the communities.

Data for the output indicators will be monitored and reported by the students on a routine basis. Every time an activity which related to the indicator takes place, the trained students record the relevant data on a reporting form which will be developed and used by the project. The data will measure and report number of: and description of ecosystems and plant species that are habitats for key natural enemies of bean pest which are identified; key invertebrate pollinators of beans and their key habitat which are established in locations and zones; lead farmers who are provided information and guidance on exploiting and maintaining agricultural biodiversity for improved crop yield; description of native plant species assessed for efficacy against key insects pest species of beans and impacts on natural enemies and pollinators, and; post graduates trained in conducting biodiversity surveys and carrying out field and laboratory based research. Where relevant the data will be disaggregated by male and female.

At the end of every month during survey periods a report on the outputs of the project will be developed by the postgraduate student working with the M&E Advisor. This monthly report will also include the outcomes and impacts data collected during baseline and after the bean harvest seasons.

FUNDING AND BUDGET

Please complete the separate Excel spreadsheet which provides the Budget for this application. Some of the questions earlier and below refer to the information in this spreadsheet.

NB: Please state all costs by financial year (1 April to 31 March) and in GBP. **Budgets submitted in other currencies will not be accepted.** Use current prices – and include anticipated inflation, as appropriate, up to 3% per annum. The Darwin Initiative cannot agree any increase in grants once awarded.

28. Cost Effectiveness

Please explain how you worked out your budget and how you will provide value for money through managing a cost effective and efficient project. You should also discuss any significant assumptions you have made when working out your budget.

Overall the costs for this action are based on experience of conducting research activities in Tanzania and Malawi by the partners on the project. Staff costs are based on the specific costs for named individuals on the project. Overheads are calculated for Kew and NRI staff at 40% but both will contribute the additional costs (60%) that cover fully over headed costs for both institutes and is calculated in the overall budget as institutional contribution.

International travel costs are based on International flights UK to Tanzania and Malawi @ £1000 and subsistence based on actual receipted expenditure. Hotel costs are based on recent experience of partners and staying at reasonably priced accommodation.

Field trial costs are based on those estimated in similar projects being undertaken by NMAIST and LUANAR.

Incidentals associated with plant collecting are based on partners' experience carrying out these activities elsewhere in the last two years.

Open Access publishing costs are based on 3 X papers in *PLoS One*.

Monitoring and Evaluation will be led by a consultant specialist Juliet Tumbo (Tanzania) who will build and develop the evaluation tools and provide these to field technicians to implement before providing the expertise to evaluate the data. Her costs are presented under 'other' in the project budget at a fixed daily rate at 10% FTE.

While DI will cover the costs of travel for Prof Geoff Gurr this will be a small fraction of the costs Charles Sturt University will contribute in his staff time.

FCO NOTIFICATIONS

Please check the box if you think that there are sensitivities that the Foreign and Commonwealth Office will need to be aware of should they want to publicise the project's success in the Darwin competition in the host country. ☐

Please indicate whether you have contacted your Foreign Ministry or the local embassy or High Commission (or equivalent) directly to discuss security issues (see Guidance Notes) and attach details of any advice you have received from them.

Yes (no written advice) ☐ **Yes, advice attached** ☐ **No** ☒

CERTIFICATION

On behalf of the trustees of **The Royal Botanic Gardens Kew**

I apply for a grant of **£288,762** in respect of **all expenditure** to be incurred during the lifetime of this project based on the activities and dates specified in the above application.

I certify that, to the best of our knowledge and belief, the statements made by us in this application are true and the information provided is correct. I am aware that this application form will form the basis of the project schedule should this application be successful.

(*This form should be signed by an individual authorised by the applicant institution to submit applications and sign contracts on their behalf.)*

- I enclose CVs for project principals and letters of support.
- Our most recent signed audited/independently verified accounts and annual report are also enclosed/can be found at: **http://www.kew.org/about/our-work/reports-accounts-plans**

Name (block capitals)	PROFESSOR KATHY WILLIS
Position in the organisation	DIRECTOR OF SCIENCE

Signed  **Date:** 1st December 2014

Stage 2 Application - Checklist for submission

	Check
Have you **read the Guidance Notes**?	✓
Have you provided **actual start and end dates** for your project?	✓
Have you indicated whether you are applying for DFID or Defra funding. NB: you cannot apply for both	✓
Have you provided your **budget based on UK government financial years** i.e. 1 April – 31 March and in GBP?	✓
Have you checked that your **budget is complete**, correctly adds up and that you have included the correct final total on the top page of the application?	✓
Has your application been **signed by a suitably authorised individual**? (clear electronic or scanned signatures are acceptable in the email)	✓
Have you included a **1 page CV for all the Principals** identified at Question 7?	✓
Have you included a **letter of support from the main partner(s) organisations** identified at Question 10?	✓
Have you **been in contact with the FCO** in the project country/ies and have you included any evidence of this?	n/a
Have you included a signed **copy of the last 2 years annual report and accounts** for the lead organisation? An electronic link to a website is acceptable.	✓
Have you **checked the Darwin website** immediately prior to submission to ensure there are no late updates?	✓

Once you have answered the questions above, please submit the application, not later than midnight GMT on Monday 1 December 2014 to Darwin-Applications@ltsi.co.uk using the application number (from your Stage 1 feedback letter) and the first few words of the project title **as the subject of your email**. If you are e-mailing supporting documentation separately please include in the subject line an indication of the number of e-mails you are sending (eg whether the e-mail is 1 of 2, 2 of 3 etc). You are not required to send a hard copy.

DATA PROTECTION ACT 1998: Applicants for grant funding must agree to any disclosure or exchange of information supplied on the application form (including the content of a declaration or undertaking) which the Department considers necessary for the administration, evaluation, monitoring and publicising of the Darwin Initiative. Application form data will also be held by contractors dealing with Darwin Initiative monitoring and evaluation. It is the responsibility of applicants to ensure that personal data can be supplied to the Department for the uses described in this paragraph. A completed application form will be taken as an agreement by the applicant and the grant/award recipient also to the following:- putting certain details (ie name, contact details and location of project work) on the Darwin Initiative and Defra websites (details relating to financial awards will not be put on the websites if requested in writing by the grant/award recipient); using personal data for the Darwin Initiative postal circulation list; and sending data to Foreign and Commonwealth Office posts outside the United Kingdom, including posts outside the European Economic Area. Confidential information relating to the project or its results and any personal data may be released on request, including under the Environmental Information Regulations, the code of Practice on Access to Government Information and the Freedom of Information Act 2000.