Analysis of Capacity Strengthening within the CEPHaS Project

Kirsten Duda, Justin Pulford, Imelda Bates

March 2022

LSTM
CENTRE FOR CAPACITY RESEARCH

CONTENTS

1 INTRODUCTION

The CEPHaS consortium sought to strengthen research capacity among a network of African and UK researchers, and their respective institutions, to fill knowledge gaps on the impacts of conservation agriculture (CA) practices on the water cycle in cultivated soils. This was largely facilitated by bringing together a cross-national, multidisciplinary network of researchers who worked together at sites where African partners have CA trials of differing ages. These included the University of Zambia's Liempe Farm, near Lusaka, Chitedze Research Station in Malawi and Domboshava Training Centre near Harare, Zimbabwe. Through collaborative planning, installation, monitoring and data interpretation at the three demonstration studies, the emphasis was on ensuring that all participants developed:

- their understanding of the contribution that other disciplines make to the problem, by working with economists and NGO partners from the outset;
- their research skills in cutting-edge methodologies;
- their generic research skills (e.g. in design or writing).

This approach can be described as collaborative and cross-disciplinary learning through hands-on, learning-centred demonstration research projects. To further complement this approach, CEPHaS delivered a wide range of training across diverse subject areas to researchers and research support staff across the CEPHaS network and supplied specialist field and laboratory equipment to consortium partners. It was anticipated that the learning-centred structure of the demonstration studies would enable participants to take the lead in establishing similar studies at other sites with new or established CA experiments, or experiments to evaluate other interventions such as agroforestry, both during and beyond the CEPHaS project lifetime. To further support this outcome, all CEPHaS study results and associated data and analyses were (and continue to be) published in fully open-access format and detailed manuals were developed in a wiki format for all methodologies employed within the demonstration sites.

In this report, we present a mixed methods evaluation of the research capacity strengthening outcomes of CEPHaS at individual and institutional levels. In particular, we focus on the perceived benefits of CEPHaS participation to both research and research support staff belonging to the network as well as perceived benefits to their respective institutions. We also examine challenges faced by CEPHaS consortium members and distil key lessons that may inform the implementation of similar initiatives in the future.

Box 1. The CEPHaS consortium

The 'strengthening Capacity in Environmental Physics, Hydrology and Statistics for conservation agriculture research' (CEPHaS) project (NE/P02095X/1 was in the GROW consortium of projects on research capacity strengthening, funded by UK Research and Innovation's (UKRI) Global Challenges Research Fund (GCRF). The project was funded for £5.1 million over 51 months. Research organisations included the University of Zimbabwe, University of Zambia, Lilongwe University of Agriculture and Natural Resources (Malawi), British Geological Survey, the University of Nottingham, Rothamsted Research and Liverpool School of Tropical Medicine (Centre for Capacity Research). CEPHaS also worked in partnership with the Zambia Agriculture Research Institute, Kasisi Agricultural Training Centre (Zambia) and the Department of Agriculture Research Services (Malawi) and collaborated with CIMMYT in Zimbabwe.

CEPHaS consisted of a consortium management unit (CMU) and six specialist working groups: 1) soil physical properties; 2) shallow geophysics; 3) hydrogeology; 4) sampling and statistics; 5) capacity research; and 6) farming systems. The six working groups were active in all three partner countries. Activities in each country were overseen by an appointed country lead. A finance lead and a laboratory lead were also appointed in each country. The CMU, country leads and working groups leads all reported to an overarching project board.

For more information about CEPHaS visit: https://www2.bgs.ac.uk/CEPHaS/index.html

Box 2. Conservation Agriculture (CA) and the need for greater research capacity

It is essential to improve the productivity of agriculture in sub-Saharan Africa while protecting land and water resources, but this is increasingly challenging in the face of climate change. Conservation agriculture (CA) practices — minimum or zero till, mulching and crop rotations — are widely promoted as 'climate smart' strategies targeted at smallholder agriculture in the region. However, the benefits of CA are the subject of wide debate, and policymakers and communities require a broad base of evidence from the natural and social sciences to support their decision making. One of the largest knowledge gaps concerning CA is how the changes in farm practice affect the physical properties of the soil, and so change the water cycle in the farmed landscape. We need to understand how CA affects the capacity of the soil profile to store water, whether and how it makes crops more resilient to droughts, and whether such changes in the soil affect the recharge of groundwater resources, on which many rural communities depend.

2 METHODOLOGY

2.1 SAMPLE FRAME

The sample frame for the survey included anyone who had attended a CEPHaS training between January 2018 and June 2021 and for whom an email address was held by CEPHaS project management (N=60). Training participants included: i) CEPHaS team members; ii) non-team members of CEPHaS institutions (students and others); and (ii) members of associated organizations. Survey participants were asked to indicate whether they would also be willing to participate in a semi-structured interview (SSI) and, if yes, to provide their name and email address. A total of 37 survey participants volunteered for SSIs via this method. Interview participants were purposively selected from this sample, with the objective of achieving representation across the final interview sample in terms of CEPHaS partner country, career stage, gender and position. In addition, invitations to participate in the SSIs were extended to 12 CEPHaS co-investigators and staff at partner institutions who had not been included in the survey sample. These participants were also approached with the objective of ensuring representation from across CEPHaS leadership and from across a range of positions including scientific, managerial and technical.

2.2 INSTRUMENT DESIGN

The survey consisted of four sections. Section one sought demographic and professional information. Section two investigated uptake, utilisation and transfer of any training provided by CEPHaS as well as potential barriers and enablers to training utilisation and transfer. Section three examined the use of any resources provided by CEPHaS as well as enablers and barriers to the use of these resources and section four explored participant experiences of CEPHaS participation more broadly. Response

options to most survey questions were closed with the participant asked to select one or multiple options from a drop-down menu. Semi-structured interviews were informed by a topic guide which covered the same four sections as included in the survey, albeit in an open-ended format. Both the survey and interview guide were designed to elicit information pertaining to both the individual participant as well as their respective University or research institution.

2.3 PROCEDURES

The survey was administered via the 'Online Surveys' platform and took approximately 10-15 minutes to complete. Participation was both anonymous and voluntary. An information sheet was included with the initial survey invitation, which was sent via email with a link to the survey form. Two 'reminder' messages were sent, also via email. The survey remained 'live' online for a 6-week period between June – August, 2021. Participants were able to complete the survey at any time during this period. Prospective interviewees were invited to participate by email and, if they accepted, a suitable date and time for an interview was agreed. All SSIs were completed remotely, via Zoom, between September 2021 and February 2022. Participation was voluntary in all cases, with each interview taking between 30 – 80 minutes to complete.

2.4 DATA ANALYSIS

Survey data were exported from online surveys into Stata/SE V.14.1 for analysis. Univariate analysis was performed to describe characteristics of the sample and for calculating frequencies and percentages. All interviews were transcribed in full and thematically analysed using a Framework approach. The framework was informed by the interview guide. Interview extracts presented in the report have been coded to ensure anonymity.

2.5 ETHICAL CONSIDERATIONS

Ethical clearance was obtained from LSTM's Research Ethics Committee (REC), UK (LSTM REC 18-038). All interview participants provided written informed consent. All survey participants were required to select a response on the online survey form that read 'I have read the study information sheet and consent to participate'. If participants selected 'yes' then they were directed to the first survey question. Participants who selected 'no' were directed to a message thanking them for taking time to consider participation and then exited the survey.

3 RESULTS

We first describe the survey and interview samples and then present key findings from both data sources under the three focal areas of: 1) training; 2) resources; and 3) experience.

3.1 PARTICIPANT CHARACTERISTICS

A total of 40 respondents completed the online survey (response rate of 67%) and 19 participants completed a semi-structured interview. As shown in Table 1, survey and interview participants were predominantly male (77.5% & 78.9%, respectively), aged between 25-44 years (65% & 68%, respectively) and graduate or early career researchers (60% & 63%, respectively). Participants were relatively evenly spread between the four CEPHaS partner countries.

Table 1. Selected characteristics of survey (N=40) and semi-structured interview participants (N=19)

Variable	**Response Options**	**Survey** Number (%)	**Interview** Number (%)
Age	18-24	O	0 (0)
	25-34	13 (32.5)	3 (15.8)
	35-44	13 (32.5)	6 (31.6)
	45-54	10 (25)	4 (21.1)
	55+	4 (10)	2 (10.5)
	Not stated	0	4 (21.1)
Gender	Male	31 (77.5)	15 (78.9)
	Female	7 (17.5)	4 (21.1)
	Prefer not to say	2 (5)	0
Location	Malawi	10 (25)	3 (15.8)
	UK	7 (17.5)	5 (26.3)
	Zambia	12 (30)	6 (31.6)
	Zimbabwe	11 (27.5)	5 (26.3)
Position	Graduate student	7 (17.5)	1 (5.3)
	Early career researcher	17 (42.5)	6 (31.6)
	Mid-career researcher	7 (17.5)	6 (31.6)
	Senior researcher	7 (17.5)	4 (21.1)
	Research support/lab staff	2 (5)	2 (10.5)
Highest Qualification	Bachelors degree	6 (15)	1 (5.3)
	Postgraduate Dip/Cert/Masters	15 (37.5)	6 (31.6)
	PhD	17 (42.5)	10 (52.6)
	Other	2 (5)	1 (5.3)
	Not stated	0	1 (5.3)

3.2 TRAININGS

3.2.1 Survey findings

72.5% (29/40) of survey participants reported attending two or more CEPHaS provided trainings, 12.5% (5/40) attended one training and 15% (6/40) did not attend a training event. The 34 participants who reported attending at least one CEPHaS training were asked to report the year in which they completed the training, the frequency with which they used this training and how they have applied the training. Participants who attended more than one training were asked to respond based on the training they used the most. As shown in Table 2, 50% of these 34 participants reported using their training at least monthly and 29% at least weekly. The most frequent applications of the training received were in support of the participants own research (68%), supporting others research (50%) or teaching within their respective institutions (38%).

Table 2. Training year, frequency of use and type of application (N=34)

Variable	Response Options	Number (%)
Training year	2018	6 (17.5)
	2019	14 (41)
	2020	6 (17.5)
	2021	8 (24)
Frequency of use	Daily	2 (6)
	Weekly	10 (29)
	Monthly	17 (50)
	Less than monthly	3 (9)
	Do not use	2 (6)
Training Application*	Teaching within my own institute	13 (38)
	Teaching outside my institute	9 (26)
	Within my own research	23 (68)
	Supporting others' research	17 (50)
	Community service	5 (15)
	Other	3 (9)

* Participants could select more than one response option

The focal training topic (i.e. the training topic for those who attended a single training or the most frequently utilised training topic for those who attended more than one training) is listed in Table 3. As shown, the focal training for the majority of survey respondents was 'R'.

Table 3. Focal training topic (N=34)

Training Topic	n (%)
R	20 (59)
Electrical Resistivity Tomography (ERT)	3 (9)
Hydrus	2 (6)
Hydro-geology	2 (6)
Installation & use of field equipment	2 (6)
Soil physics training: field monitoring	1 (3)
XCT & soil physics training	1 (3)
Soil & water sampling	1 (3)
Working with Delta T loggers	1 (3)
All training related to WG1	1 (3)

When asked 'apart from teaching, have you transferred this training in any other way?', 24 out of these 34 participants responded 'yes'. Table 4 presents the various ways in which these 24 participants reported transferring knowledge/skills gained from a CEPHaS training. As shown, knowledge/skills transfer primarily took place in the context of student supervision or supporting/supervising institutional colleagues.

Table 4. How CEPHaS training was transferred (N=24)

Response Option*	**Number (%)**
Support/supervising students	17(71)
Supporting/supervising colleagues – internal	15 (62.5)
Supporting/supervising colleagues – external	9 (37.5)
Support/guiding the general public	4 (17)
Other	1 (4)

* Participants could select more than one response option

All participants who reported attending or transferring a training were asked to identify, from a list of specified response options, enablers or barriers to utilising or transferring CEPHaS training. As shown in Table 5, the most frequently reported enablers to utilising and transferring training were 'training was applicable to my work', (74% & 75%, respectively), 'having the applicable knowledge/skillset' (62% & 71%, respectively) and 'sufficient training' and 'sufficient mentorship/support' (both 53% & 54%, respectively). The most frequently reported barriers included 'insufficient time' (30% & 24%, respectively) and 'insufficient access to equipment' (15% & 9%, respectively). However, over 50% of respondents reported 'no barriers' to either the use or transfer of training.

Table 5. Reported enablers and barriers to training application and transfer

Response Option	**Training…**	
	Application n (%)	Transfer n (%)
Enablers	*N=34*	*N=24**
Mentorship/support	18 (53)	13 (54)
Access to equipment	7 (21)	5 (21)
Access to guidelines	12 (35)	10 (42)
Having the applicable knowledge/skillset	21 (62)	17 (71)
Sufficient training	18 (53)	13 (54)
Sufficient time	7 (21)	6 (25)
Training was applicable to my work	25 (74)	18 (75)
Personal interest in the material	19 (56)	10 (42)
Other	1 (3)	1 (4)
Barriers	*N=34*	*N=34*
Insufficient mentorship/support	0 (0)	1 (3)
Insufficient access to equipment	5 (15)	3 (9)
Insufficient access to guidelines	0 (0)	1 (3)
Insufficient knowledge/skillset	2 (6)	1 (3)
Insufficient training	2 (6)	1 (3)
Insufficient time	10 (30)	8 (24)
Training was not applicable to my work	1 (3)	0 (0)
No personal interest in the material	0 (0)	1 (3)
There were no barriers	19 (56)	22 (65)
Other	2 (6)	0 (0)

* Only participants who reported transferring CEPHaS training were asked to report enablers.

3.2.2 Interview findings

3.2.2.1 Individual benefits

The knowledge provided through the CEPHaS trainings was noted by participants as one of the greatest benefits of being a part of the CEPHaS project.

The main benefit that I'm seeing at the moment is the knowledge itself and understanding the process. Because the concepts are new to me, and the knowledge that I'm having, I know, is quite unique knowledge, and not most of the people having at the moment. I could say it's the knowledge that's the best benefit from the training that I've had so far.

- Postgraduate research fellow, Malawi, LUANAR, Male

CEPHaS trainings supported participants in developing better individual working processes. A more meticulous approach to project planning and data management was introduced to participants for the CEPHaS project activities. Participants then took this new perspective and approach to their own work with more detailed planning and flexible time management.

Additionally, the training enabled participants to follow detailed processes that allowed them to see how project elements were connected and provided a process to track and trace errors to ensure data validity.

I have been able to see now, wow, you really need to think about every detail. So, sometimes even when I'm planning my own field work I get to plan it in that detail. And then we decided. I am beginning to realise that some things I would think maybe before that we'll get everything done today, but, no, it doesn't work that way. You have to give time for everything. When you really get to see that detail then you'll be able to say, okay, maybe I need two days in the field or I need a little bit more on, things like that. So, that's now on the planning part of it… when I say it broadens your horizons, so it's also something when you interact with other people it also changes your mindset. So, I think this is the most important, thing to have that change of a mindset. … For example, you would be delayed and then when you are delayed by something beyond your control now you would get to do another task while you wait for that other person to come through.

- Research assistant & lecturer, Zambia, UNZA, Male

CEPHaS trainings provided specific skillsets that were required for CEPHaS project activities, but simultaneously provided participants with new skills that they could use to support their other research activities. Within the interviews, the skillsets participants most frequently mentioned were, training in the R software, particularly as it applied to data tracking, analysis, and visual presentation, and equipment use and ability to troubleshoot equipment problems.

I can say it improved the way I understand and also I do my research, mainly handling secondary data, reports and so forth, as now I'm working on trying to do a meta-analysis, which probably I could not have done if I was out of CEPHaS.

- Research Assistant, Zimbabwe, UZ, Male

3.2.2.2 Knowledge transfer

Knowledge transfer through informal context was noted by numerous participants. Knowledge transfer of the skillsets acquired through CEPHaS training was primarily on a one-to-one needs only basis with other students and colleagues. Knowledge transfer occurred both within and external to CEPHaS project.

I cannot necessarily say that I've transferred the knowledge but, because I'm not necessarily teaching them how to use R itself. But I was assisting them to analyse their data. Especially, to produce the type of graphs that they needed and the other analytical things that they wanted from there. But not necessarily teaching them how to use the tool as I learnt it.

- Postgraduate research fellow, Malawi, LUANAR, Male

Within this context, students from within their own institute, from other institutes within their country, and from institutes in different countries were supported by individuals who attended CEPHaS trainings. Opportunities for knowledge transfer were facilitated both by other members of the CEPHaS staff and colleagues within the institutes who knew of individuals within their own institutes who had benefitted from the CEPHaS trainings. Transfer of knowledge to staff and students was facilitated by existing CEPHaS connections and word-of-mouth. These actions and relationships worked to initiate a knowledge network.

They knew that I could assist them with their data when they asked around, who could assist them with maybe some data analysis.

- Postgraduate research fellow, Malawi, LUANAR, Male

Specific skills acquired from trainings that participants noted transferring to others included data management, data analysis and data presentation (graph creation). Much of this was centred on the transfer of R skills, but it was not limited to skillsets pertaining to R. One other key area of note for knowledge transference was the financial training and support received throughout the project.

Knowledge transfer through a formal incorporation into a class was only noted by one participant, but several participants noted using the CEPHaS field sites and introducing the students to the techniques and equipment used in the CEPHaS project through field trips. The knowledge obtained through the CEPHaS trainings influenced their perspectives and was considered when developing new teaching materials.

Already I'm applying some of the things I learnt to teaching. Also it has helped me to look at the courses I teach from another angle and try to review the content and things….There are things that I've incorporated into the course. To give an example, from the soil physics there are these instruments we received, profile probes, measuring water content. So, at first we would maybe just look at the three pillar ones, the FDR, that's what we had before. But now also we've been able to incorporate this and say, okay, there's also these other kinds of instruments with resistance tomography measurement which you can interpret into water content data or as soil property. So, that's something I've been able to add to the courses as well, found a way to incorporate it.

- Research assistant & lecturer, Zambia, UNZA, Male

3.2.2.3 Institutional benefits

The primary area that participants felt institutes benefitted through the trainings was that the staff at these institutes now had new knowledge and skillsets from participating in the trainings, and these skillsets complimented the new resources that they had been provided, allowing for them to expand upon their research and better support students. Both of which were felt to ultimately affect the quality of the work, teaching and prestige of the institutes in which they worked.

Having hands on experience using equipment in their training experience, allowed them to be immersed and trained in these skillsets that would provide benefits to the field in which they worked.

Where your staff get to know a little bit more and gather a little bit more knowledge. But also apart from constant staff development it's also being able to have staff who really work with the instruments and have skills. They develop some skills apart from just the knowledge so they can really be able to work with different things in that field.

- Research assistant & lecturer, Zambia, UNZA, Male

Having training in fields beyond their academic expertise and having a range of staff trained through the CEPHaS project was seen as ways that the institute would benefit by having a multitude of staff in different positions who could communicate and collaborate beyond their specific niche.

Looking at our lab technicians, some of my colleagues where they're academics people, they have been trained. That is a long-lasting knowledge that will be used for uplifting some of the issues that we do for our institution. For me also being trained in terms of the geophysics, it means I'm capable to say if somebody else brings in the issue of geophysics, I should be able to address and the institution will benefit or maybe they can be able to collaborate in another project.

- Senior Lecturer & Co-PI, Malawi, LUANAR, Male

I think they're long-lasting. For example, the skills, the competencies that I have now in terms of data analysis using R, as I said earlier on, I'm actually imparting that knowledge to my students that I supervise, postgraduates and undergraduates. It's something that has remained with me as it were.

- Postdoc & lecturer, Zimbabwe, UZ, Male

The knowledge received by participants was seen as long lasting and would continue to be used and passed on as it facilitated more convenient processes for staff and students.

Now our students can actually do their experimental fieldwork much quicker than in the past courtesy of the equipment that we received from the project. The trainings are really key. The knowledge is remaining with us and we can actually then impart it to our students and even fellow staff members who also want to use the equipment that was bought under CEPHaS.

- Postdoc & lecturer, Zimbabwe, UZ, Male

Having additional staff trained supported the more knowledgeable staff in task completion and allowed them to increase the amount of work that they could complete.

Then, secondly, we also had research assistants who were working on the project, data collection, downloading of the data and so on. That capacity building in terms of having more than me undertaking the training and being able to use the laboratory equipment and the field equipment, I think that has been a plus in terms of capacitation of the resource person that we have here. In case I'm not around, someone can actually use the equipment and help students and other staff members to collect data and so on.

- Postdoc & lecturer, Zimbabwe, UZ, Male

This training was seen as something that might go beyond the institutes as the individuals trained at these institutes would eventually seek work across a variety of complimentary sectors working in the field of conservation agriculture.

I would think that's sustainable because training is given through a training institution. The training institution also trains other people and in the long run those who are trained then also train others. Because for us we've been training people who will be funders or with government and many other places, non-governmental organisations. So, in that way it becomes sustainable because now this skill is being transferred all the time, it's not kept to one person.

- Research assistant & lecturer, Zambia, UNZA, Male

Beyond the scientific trainings, the project management and financial training was seen as a key benefit of the project. This was noted by a range of individuals, including those who worked in finance, were responsible for project management, and those working specifically on the scientific aspects of the project who heard about the financial processing support provided by the CEPHaS project.

CEPHaS has also been very key in terms of, we're not only focusing on doing field measurements and lab measurements, we also had some site training on project management that were actually coordinated by Fiona and … how you write a proposal or how you manage project funds and things like that....We can properly prepare budgets. We can also do reports. We can write comprehensive reports and things like that. That has also been some capacitation in that regard. Even in the project, we also had a finance officer who was working closely with Fiona. They went through some trainings also in how to prepare budgets, how to prepare projected expenditures and so on. Besides our soil science in environment lab, the CEPHaS project also capacitated even the business department in terms of how to do financing, how to do project planning and so on. It has really been key in terms of capacity building in the hardcore sciences, in finance, project management.

- Postdoc & lecturer, Zimbabwe, UZ, Male

3.2.2.4 Training quality and style

The training was largely viewed as interdisciplinary within the field of agriculture, and participants felt they had been provided with expertise from a breadth of knowledge and within niche areas to which they otherwise would not have been exposed.

One of the aspects widely appreciated by participants was that the trainings covered basic science within each topic area so that all working group members were on the same page. This was seen as beneficial to both individual growth and project functionality. Trainings across all subjects were taught at a very basic level that was appreciated by participants, and they felt that this allowed all participants to gain a solid understanding of a subject matter that they needed to support the project, even if they did not have substantial prior knowledge of the subject area.

I don't think I would have received that kind of training, because it was really hands-on, and I also liked the way that it was well structured, we would do it in phases. I think that way, it was really beneficial to the rest of the project team here in Zimbabwe, particularly myself, in terms of going through the steps.

- Postdoc & lecturer, Zimbabwe, UZ, Male

The majority of participants said the trainings they received could not have been accessed elsewhere at all or with ease. Where participants felt they could have accessed training elsewhere, they thought that if they had searched the internet, they might have found information and training on some subject areas, such as the R software, but that this may have been prohibited by cost and designating time outside of their job.

Training materials were noted frequently as being an immense support both during the trainings, and subsequent work throughout the CEPHaS project as they were both easy to understand and accessible.

Additionally, trainers were accessible throughout training and to support project activities post end of training. One of the most valuable aspects of the trainings for participants were the quantity of individuals who were training them and the breadth of experience that these individuals had. Participants felt that the trainings provided them with an interdisciplinary support network within the field of conservation agriculture.

It was my first time to be introduced to R. I had never used R, and [the trainer's name] was very patient in terms of starting from scratch, the basics and how to actually use the R in data analysis, how to write codes and so on. It really changed the way I used to do my statistical analysis with my data. I can't really say I'm a guru in R, but I can understand what's happening and I can also even assist students that I supervise to do data analysis.

- Postdoc & lecturer, Zimbabwe, UZ, Male

The trainings were excellent. I think I have gained confidence in using R. Originally I always said that I will not use it because after all, I already know how to analyse data with other software. But the encouragement within the project was, shall we use this open source which is like, the majority of people use it and it is freeware. I didn't feel confident because of the use of coding language. I participated in the training round one. I didn't like it. But the second time, I felt moderately confident that I could write some code. Eventually, I was able to use it to actually do my own data analysis. The benefit is that I was able to expand my expertise in using another software to analyse experimental data, which I think was a great benefit to me…… Before R, I would use Genstat, I would use SPSS. Of course, for spatial statistics, I would use ArcGIS and other remote sensing software.

- Lecturer & researcher, Zambia, UNZA, Female

The learning process was hands on and supportive.

It was learning by doing. It wasn't presentations, it was exercises, because one will give a short presentation then there's an exercise. When you do it, there are colleagues who are there to give support and feedback if one has a question, one is stuck. It was learning by doing. One actually practiced with some actual data, so it was easy to learn.

- Lecturer & researcher, Zambia, UNZA, Female

Overall, the CEPHaS training style and support structure was seen as unique.

Most of the projects that I participated in previously before CEPHaS, they were just focused on the hardcore sciences, on project activity that has to do with the hardcore research questions that had to be answered. But with CEPHaS, also it was quite holistic and inclusive in that, we all had project partners coming in. Finance, human resources, the scientists, administrators, where we were actually a much broader team than in other projects that I actually participated in in the past, where we only have a meeting of scientists alone and no other support staff to help the projects move on....The change is to the individuals because of their inclusion. Now, I think I work closely with [name of finance team member] on finances. He is now producing the financial reports much quicker than what he used to do in the past. I think also he understands....In the past, we used to have a big divide between the finance guys and researchers. Now, because of this interaction, where he was also part of the trainings, he would understand what we are going through and the activities that has been done. The planning is much quicker and much faster now because he also understands what we'll be doing in the field and in the labs and so on.

- Postdoc & lecturer, Zimbabwe, UZ, Male

3.2.2.5 Reported challenges and suggested improvements

Common challenges and/or suggested improvements reported by interview participants included some content being niche, the limited time to absorb the information, the limitations of the Covid pandemic and the timing of project activities in relation to the trainings.

One participant noted that the trainings provided niche knowledge. Trainings and knowledge gained was identified as niche with limited transferability in the current country climate (Malawi) as the equipment they were trained in is only available at that specific organisation, and the processes that they were trained in were only used for a specific set of experiments conducted under the CEPHaS project. For an employee only hired for the CEPHaS project and not a permanent employee of the university, this was seen as highly useful knowledge and experience for these specific activities, but lending very limited transferability outside of the university and specifically the CEPHaS context.

Time to absorb the training material was limited. Multiple participants commented that the trainings covered large amounts of material and that some of this material took a considerable amount of time to understand. Participants felt that they needed more time to absorb this material to fully understand it.

I think the contents should have been reduced in some of the training modules. There's been a lot that we were given to study. To master. To get trained into. …….I think the content of the materials, I think there was too much to handle, depending on the period of time that you had.

- Postgraduate research fellow, Malawi, LUANAR, Male

The Covid pandemic was noted by almost all participants as a negative that affected the experience of participating in the CEPHaS trainings. Participants generally preferred trainings conducted face-to-face and felt that the trainings conducted prior to pandemic were more enjoyable and generally better. Having that connection and the ability to connect with trainers and colleagues in person enhanced and was more conducive to a positive training experience. Online trainings conducted during the pandemic were still appreciated as the trainers were readily available online to answer questions and it was supportive to the learning experience to have recordings that participants could refer back to.

I can differentiate the way that the trainings were handled differently COVID issues and after the COVID. There was a lot of difference. Before the COVID, the quality was very good because there was physical interaction, and it was easy to discuss. Meet up with the trainers. And talk issues internally. We still have time together. But most of the trainings that we conducted online, the content was good. But, you know, it's difficult, it's too difficult, maybe, to grasp some of the things. To learn online.

- Postgraduate research fellow, Malawi, LUANAR, Male

We would know that during network meetings, we actually set aside time to do some training, whether working group one, working group two or working group three or working group four. But then when COVID came in, we could not do the face-to-face interactions and do the trainings. It disrupted our training schedules because we could not do the face-to-face network meetings and also the trainings. It disrupted the training programme and we really felt it with regards to some field equipment that we have here. Sometimes we have some malfunctioning of some of the equipment, and then we had to exchange emails with our project partners in the UK. It's different when someone's there and they explain to you, then you do it step by step. As opposed to when they actually have to write an email or have a Zoom meeting to actually diagnose the problem and things like that. It affected our operations, our training programme.....There was, one, delay in terms of project activities....Even here, because of the lockdowns, we could not go to the field regularly to download data and things like that. It affected our operations because of this COVID-19 outbreak.

- Postdoc & lecturer, Zimbabwe, UZ, Male

The timing of the trainings in relation to when the associated activities occurred was not always ideal for participants. Participants highlighted that trainings needed to be done in a way that allows for

training material needs to be understood but not have too much time pass before it is applied in the field. Goldie Locks timing for trainings - not too early, not too late.

3.3 RESOURCES

3.3.1 Survey findings

All survey participants were presented with a list of resources supplied by CEPHaS and were asked to identify those to which: A) they had access to; B) had used during the course of CEPHaS; and C) had used most often (when more than one resource had been used). As shown in Table 6, most participants had access to, and had used, training materials, equipment and software supplied by CEPHaS; however, the resource used most often by 60% of participants was supplied equipment.

Table 6. Resource access and use (N=40)

Resource	**Access** n (%)	**Used** n (%)	**Most used** n (%)
Equipment	29 (72.5)	29 (72.5)	24 (60)
Software	26 (65)	26 (65)	14 (35)
Training materials	31 (77.5)	30 (75)	6 (15)
Standard operating procedures (SOPS)	21 (52.5)	17 (42.5)	1 (2.5)
No access to any of these	1 (2.5)	-	-
Other	0 (0)	1 (2.5)	0 (0)

Participants were asked how frequently they used the resources supplied by CEPHaS and for what purpose. For participants who reported using more than one resource, they were asked to respond based on the resource that they utilise the most. As shown in Table 7, almost all participants used the focal resource at least once a month or more (92.5%) most often in support of their own research (75%) or teaching within their own institution (47.5%).

Table 7. Resource frequency of use and type of application (N=34)

Variable	**Response Options**	**Number (%)**
Frequency of Use	Daily	11 (27.5)
	Weekly	8 (20)
	Monthly	18 (45)
	Less than monthly	3 (7.5)
	Do not use	0
Resource Application*	Teaching within my own institute	19 (47.5)
	Teaching outside my institute	7 (17.5)
	Within my own research	30 (75)
	Supporting others' research	15 (37.5)
	Community service	4 (10)
	Other	4 (10)

* Participants could select more than one response option

All participants were asked to identify, from a list of specified response options, enablers or barriers to utilising CEPHaS provided resources. As shown in Table 8, the most frequently reported enablers to resource use were 'resource was applicable to my work', (65%) and 'having the applicable knowledge/skillset' (57.5%). The most frequently reported barriers included 'insufficient time' (20%) and 'insufficient training' (10%). However, 67.5% of respondents reported 'no barriers' to resource use.

Table 8. Reported enablers and barriers to CEPHaS provided resource use

Response Option	**Training…** Application n (%)
Enablers	
Mentorship/support	13 (32.5)
Access to equipment	21 (52.5)
Access to guidelines	20 (50)
Having the applicable knowledge/skillset	23 (57.5)
Sufficient training	21 (52.5)
Sufficient time	14 (35)
Resource was applicable to my work	26 (65)
Personal interest in the resources	21 (52.5)
Other	0
Barriers	
Insufficient mentorship/support	3 (7.5)
Insufficient access to equipment	3 (7.5)
Insufficient access to guidelines	2 (5)
Insufficient knowledge/skillset	3 (7.5)
Insufficient training	4 (10)
Insufficient time	8 (20)
Resource was not applicable to my work	0
No personal interest in the resource	0
There were no barriers	27 (67.5)
Other	3 (7.5)

3.3.2 Interview findings

3.3.2.1 Training materials

Training materials were frequently noted by participants as key resources provided by CEPHaS. Bespoke training manuals created by UK partner institutes to accompany equipment and software trainings were identified as easy to understand and provided participants with guidance that they felt might not otherwise have been available by existing written resources. Participants felt that these training manuals not only supported the CEPHaS project, but as the CEPHaS equipment would remain with the institutes after the duration of the project, that the training manuals would also serve as guidance documents for future research projects and support the training of students. In addition to the bespoke training manuals, participants also noted that the R scripts provided to support their work on the CEPHaS project were a great support throughout the duration of the project. However, these scripts were noted as fairly limited in value outside of the CEPHaS project unless the work of the CEPHaS project was to continue.

We have manuals to do with data collection. We have manuals to do with operation of equipment. We have manuals to do with statistical analysis of data. We have several manuals that were actually developed under CEPHaS and we never used to have those. Now with my students, if we want to do an experiment on soil water measurement, I'll just draw that manual, this is how you're supposed to do it and this is the frequency of data collection and things like that. We have legacy protocols that we'll actually remain with post-project period.... Definitely (in the future) they will be of use by researchers who want to do work along the lines of soil physics, soil water measurements and so on, because they are quite comprehensive… in the past what we used to do, we didn't have a systematic way of collecting the data. Then [name of project lead] said, no, if the data is not collected systematically, it's very difficult to reach at a comprehensive conclusion about treatment differences and so on. That was really something that we really benefitted from in terms of the planning and the systematic collection of data, both in the lab and in the field.

- Postdoc & lecturer, Zimbabwe, UZ, Male

3.3.2.2 Equipment

Scientific equipment provided by the CEPHaS project was seen as a key benefit to both individuals and institutions. Having the breadth and bulk of new equipment was seen as a massive benefit that would faster and more effective research, expand research opportunities, increase the teaching potential, and bring prestige to the institutes.

CEPHaS has really capacitated the institution in terms of buying. The project bought equipment to measure soil water in the labs and soil water and temperature, matric potential in the field. We actually did the installation, it was really hands-on, starting from the theory and going into the field, how to store the equipment and so on.

- Postdoc & lecturer, Zimbabwe, UZ, Male

This new equipment eased time constraints and made processes more relevant within context.

Then you will create that relevance in society. Because before if you wanted to know something about the soil you always had to take it from where it is, bring it to the lab and run it through your physical analysis you are doing. But now it's much easier to just use these new technologies… You just pin something in the field, like we were doing with electrical resistivity tomography. You just pin some electrodes in the field, you'll get your measurements. Then you'll go back and analyse with the software whatever data you collected. Also the reward is moving away from this physical mode of analysis to incorporating more of software technologies…

- Research assistant & lecturer, Zambia, UNZA, Male

In addition to the scientific equipment provided by the CEPHaS project, several participants recognised the laptops provided by CEPHaS as substantially valuable resources. Being provided laptops meant that employees of the project did not have to rely on desktop computers located in their place of work. This was particularly useful for employees who were not permanent employees at partner institutes and instead were only employed for the duration of the CEPHaS project. Additionally, decreased mobility of all staff due to the Covid pandemic, meant that project laptops facilitated remote working.

For the laptop, I think it really improved my work, because I was using one old one which was sometimes slow, always freezing and so forth. When I got this one, I can now work efficiently and probably sometimes meeting some deadlines and so forth.

- Research Assistant, Zimbabwe, UZ, Male

3.3.2.3 Open source software

Open source software, such as R, although not specifically provided by the CEPHaS project, were of great value to participants. As CEPHaS provided trainings for R, CEPHaS facilitated the use of this open source software. Both the R trainings and the R software were repeatedly noted by participants as of both current and future value.

When you talk about the uniqueness, in terms of the approach that work group one, two, and three uses. It's all in terms of the instrumentation and the way the data is captured and analysed. It's the visualisations that are produced. It's something which I think I've not seen any other institution doing it in Malawi. Analysts, they are maybe PhD students doing similar work elsewhere using data collected from Malawi. But not doing the actual research here in Malawi.

- Postgraduate research fellow, Malawi, LUANAR, Male

The data management, analysis and data visualization components of R were noted as key and were utilised by participants not just for the CEPHaS project but also for other projects within their institutes. Having knowledge of this as a free software programme also meant that they could utilise this resource to further teach students in the classroom. For individuals using other statistical software, such as STATA, R was seen not as a replacement, but as a complimentary tool, as each software was identified as having pros and cons.

Ultimately, the R software was seen as something that could be used beyond the CEPHaS project, and would strengthen the capacity of both the participants and the institutes, as it would continue to be used by those at the partner institutes who participated in the CEPHaS R training and the students and colleagues they supported.

But with some scripts, which if I didn't understand very well, I could contact them and say, okay, I'm analysing, this is how my data is, this is the analysis I have done, what do you think? Something like that.

- Lecturer & researcher, Zambia, UNZA, Female

3.3.2.4 Financial templates & guidelines

One of the resources provided through the CEPHaS formal and informal human resource/financial trainings was a financial/ invoice template. This template was provided to streamline and provide detailed transparency of the CEPHaS financial transactions. Partners participating in accounting across the participating institutes noted that this template allowed individual partner institutes to provide information that might otherwise have been unaccounted for within the current parameters of an individual institutes' mandated processes, and this streamlined inter-institutional processes. This supported the CEPHaS grant accountability, but also provided a process and template that could be used within the human resource department for other grants. It was reported by one participant that a colleague on a different project with one of the partner institutes felt that they were benefitting from this template and training, as the staff member at the partner institute knew what information would be required for accounting within an international project.

3.3.2.5 Enhanced laboratory facilities

Equipment was seen as one of the greatest capacity strengthening elements provided through CEPHaS. CEPHaS replaced equipment that was outdated and no longer functioned properly as well

providing new equipment. Both laboratory and field equipment were noted as greatly beneficial to the partner institutes in Malawi, Zambia and Zimbabwe. It was acknowledged that although the CEPHaS project required this equipment, having this equipment to enhance their laboratories provided a multitude of benefits to the institutions.

In fact, we were able to get our colleagues from Malawi and Zimbabwe to come for some more training with us here at our lab at UNZA in Zambia. We have highly-trained staff. They know how to operate the equipment and the lab is functional. We have students, so we'll continue to use it for training as well as for making other research related measurements….It's just by our department. If other people want to use it, for example, agriculture engineering, they have to make a request and then the permission can be given for them to use. But otherwise, mainly it is for us here. Opportunities exist for other people to use it in the university, but there's a procedure. Just like when we want to use their lab, for example, if in our chemistry lab maybe we have a challenge that day our distiller is not working, we will go to another faculty and ask if our staff can use their distiller. There's a procedure to use equipment in another faculty.

- Lecturer & researcher, Zambia, UNZA, Female

Having new equipment was seen as strengthening the calibre of the institute laboratories and that the institute would receive a multitude of benefits as a result of these enhanced laboratories.

For example, LUANAR, did not have a soil physics laboratory before. It was there in theory and things were recording, but practically not much. But the coming in of the CEPHaS project to LUANAR, with a good physics laboratory. Most of the equipment that they need. And these are the things which will not be used only for CEPHaS.

- Postgraduate research fellow, Malawi, LUANAR, Male

Having new equipment provided possibility for new experimentation and new research opportunities that previously would have been unattainable without this equipment.

Additionally, enhanced laboratories provides new opportunities to the students at these institutes. Students could now explore new areas of research as they would have access to equipment both in their coursework and supervised projects.

A lot of equipment courtesy of CEPHaS that we actually are using with students to do postgraduate training and so on. It really changed the way we used to do fieldwork and lab work with regards to soil physics.

- Postdoc & lecturer, Zimbabwe, UZ, Male

Having enhanced laboratories was seen as strengthened prestige of their institute. Participants felt that having laboratories like this would promote collaborations between their institute and other organisations both within and outside of their countries, as other organisations would see them as having the equipment and skills that would facilitate good research.

I can say the institution has really benefitted in a number of ways. One, CEPHaS has helped to modernise our laboratories. Our soil physics laboratory has actually been modernised. We now have modern laboratory equipment to measure soil water, to measure soil texture, drying of samples. In terms of infrastructure and modernisation of the university infrastructure in particular, CEPHaS has been handy in that regard. We're talking of both lab and field equipment, so now we can boast of modern equipment that we can actually use. I think the university has really benefitted in that regard.

- Postdoc & lecturer, Zimbabwe, UZ, Male

The prestige of enhanced laboratories would not just support the researchers but provide new opportunities for their students. This in turn was seen as something that would attract more students. These laboratories coupled with CEPHaS trainings could be used to develop further formalised training at the institutes.

These enhanced laboratories were in turn seen as something that could enhance services delivered by the institute to other partners working within the field of conservation agriculture.

In the long run of course. If you are to look at it in the long run, then it would be improved service delivery also to various stakeholders. Because for us we have a service lab as well where people could come and consult. So, if this lab is able to do things a little bit faster and more efficiently, is then of course more representative because you're also covering a larger area. With these other technologies people will be able to benefit as well from that…. So, it's much easier, then you can go into the field and get out data on the spot and then analyse it. Then you have your required information within a short period of time other than before it would take a lot more time like months or something like this.

- Research assistant & lecturer, Zambia, UNZA, Male

3.3.2.6 Institutional assessment

As a part of the CEPHaS project, an initial capacity strengthening assessment was undertaken to identify potential areas that could be supported throughout the duration of the project. One participant noted this as something that was of value to their institute.

For our institution, I think we did an institutional assessment. There were some things that they recommended we could improve on. For example, the grants of… I'm trying now to remember, I may be wrong. Institutional assessment was one which was submitted to the dean, I think. The benefit in that they could look at even if it's not work that CEPHaS was going to change, but they just assessed the institution and how it operates. I think that was a good benefit…It looked at the various structures in the institution, then highlighted the things that were working very well that were in place and then made some recommendations. The recommendations were all things that could be done, even if they won't be done by CEPHaS.

- Lecturer & researcher, Zambia, UNZA, Female

3.4 EXPERIENCE

3.4.1 Survey findings

All survey participants were presented with a list of research-related activities (see Table 10) and asked to identify which, if any, they: had experienced as a result of CEPHaS participation; they had experienced for the first time as a result of CEPHaS participation; and had been most useful to them and their respective institution. As shown in Table 9, 'data analysis' (85%) and 'field work' (82.5%) were the most widely reported activities, with the former also the activity most often experienced for the first time (20%) and the activity considered most useful for the individual (27.5%) and their respective institution (25%).

Table 9. Activities experienced during CEPHaS, experienced for the first time and most useful to the individual participant and their respective institution (N=40)

Response Options	**Experienced** n (%)	**First time*** n (%)	**Most - You** n (%)	**Most – Inst.** n (%)
Field work	33 (82.5)	3 (7.5)	9 (22.5)	7 (17.5)
Data analysis	34 (85)	8 (20)	11 (27.5)	10 (25)
Laboratory work	23 (57.5)	4 (10)	3 (7.5)	7 (17.5)
Teaching/training others	25 (62.5)	3 (7.5)	2 (5)	4 (10)
Career progression opps.	11 (27.5)	4 (10)	3 (7.5)	0 (0)
Networking/collaborations	30 (75)	7 (17.5)	14 (35)	10 (25)
Publications opps.	25 (62.5)	7 (17.5)	3 (7.5)	4 (10)
Mentorship	21 (52.5)	3 (7.5)	0 (0)	1 (2.5)
Conference presentation	9 (22.5)	3 (7.5)	1 (2.5)	2 (5)
Research support	19 (47.5)	2 (5)	3 (7.5)	5 (12.5)
Leadership responsibilities	21 (52.5)	4 (10)	2 (5)	0 (0)
Attending trainings	27 (67.5)	2 (5)	2 (5)	0 (0)
Other	0 (0)	0 (0)	0 (0)	1 (2.5)

* n=20 (50%) participants did not experience any of these for the first time

Survey participants were also asked via open ended questions if there was anything else CEPHaS could have done to support them or their respective institutions. Verbatim responses are listed in Table 10.

Table 10. Participant suggestions as to additional support CEPHaS could have provided them or their respective institutions

Is there anything else that CEPHAS could have done to support you?
Training & publications
Work exchange visits
Incorporating remote sensor techniques to sensor measurement
Further collaboration
The necessary practical data analysis trainings could be introduced right at the beginning of the project to enable (me) utilize the knowledge within the life of the project
Longer time period
More training + exposure through laboratory visits
Scientific writing training
Link me to senior researchers for further networking/collaboration
Continued collaboration + access to more research funding
Training could have been more rigorous
Master degree scholarships
Providing more equipment
Career development
Further assistance to run own research
Is there anything else CEPHaS could have done to support your institution?
Exchange visits to other institutions in UK
Funding for postgraduate training x2
Future research collaborations with partners
CEPHaS could enforce local management to allow technical field support personnel (like us) to master writing articles, manuscripts and other communication materials

it should have spanned for a longer period of time so I could better understand or gain experience with the new experiences it brought us
Acquire more equipment x3
Training of postgraduate students
Maintenance of equity after project ends
ZARI has a lot of information in hardcopy form so I would be happy if CEPHaS helped out with resources to digitize the information and keep it in forms that can easily be accessed by everyone in all the parts of the world
More funding and training
Face to face training
Special Hydro-Geology Laboratory that will analyse and store Groundwater data for the benefit of CEPHaS future projects and Malawi country at large

3.4.2 Interview findings

3.4.2.1 Expanded network

One of the most valuable aspects of the CEPHaS project identified by participants beyond their new skillsets, was their newly expanded network across institutes and countries that they felt the consortium had provided them. This was generally felt across all participants regardless of their institute's location. However, the nature of this network was seen through a slightly different lens, based on whether they were a north or south based institute.

Within the global south, the new, expanded network was seen as multi-faceted, providing the opportunity for increased collaboration in broad terms that covered research areas, project partnerships, individual training and career development opportunities, and enhanced resources.

Within the global north, the new, expanded network was generally seen in slightly more linear terms, providing the opportunity for exploring research applications in new contexts and new partners for grant applications and publications.

Having the support of this network to troubleshoot problems when applying new skillsets was seen as beneficial to all both during the project and for future research applications, though this area was noted more frequently by southern partners.

Regardless of location, participants felt that the consortium had provided them with a network for future collaboration. This was seen a great benefit in an academic environment in which the primary drivers are often funding applications and novel publications.

I feel confident, like for example, to speak with colleagues who are in Malawi, speak with colleagues who are in Zimbabwe, speak with colleagues who are in the UK. For me, I feel the network was well built.

- Lecturer & researcher, Zambia, UNZA, Female

Scientific interdisciplinary exchange and exposure was also seen as something that was mutually beneficial across partner institutes. New perspectives, based on experiences and expertise, were valued and applied to develop both a new approach and equipment modifications to suite the context in which they were being applied. In one instance it was noted that equipment functionality was modified due to the participants learning the effects of climatic conditions on the equipment in new contexts.

Similarly, cultural exchange was additionally seen as mutually beneficial. Learning different cultural expectations and differences in institutional processes were seen as areas that were informative and knowledge that could be used to form stronger projects and partnerships in the future. They were also seen as individually informative and unique experiences.

And my travel to most other countries. The trainings that I've managed to get while still there. It's another unique thing that will impact me in the long term. Because it's kind of an exposure experience which you cannot get just from email.

- Postgraduate research fellow, Malawi, LUANAR, Male

Cultural exchange and learning occurred in a myriad of ways that were seen as beneficial and enlightening for individuals. They gained new perspectives and insights on areas of life and other individuals, institutes and cultures that provided them with a broader understanding of others and provided them with new knowledge for future interactions.

They like to have different foods. Also, some of the things like the way they cook is different. But also, in terms of the work style, for example, if it is time to start, some are a little bit more relaxed about starting time, others maybe are too strict. Those exchanges, they help to open the mind and to be adaptable and flexible to how things can be accomplished while respecting each other.

- Lecturer & researcher, Zambia, UNZA, Female

These sentiments were echoed by participants from both the North and South.

There was another woman as well that said that she thought that the north kind of institutions had their time and they wanted the African partners to work with the same timescales. She said, you've got to realise, appreciate and understand that we work on different timescales and that is our way of doing things. I just think, again, some of these things seems really obvious. When you say you're like, well, yes, of course. But unless somebody says it, unless you're part of these talks and you listen to the people and really listen to the people, you perhaps don't appreciate that maybe you have been living in a bit of a bubble and you don't see things from other people's perspective. It's a lot to do with that.
- Research Support Staff, United Kingdom, BGS, Female

In one instance this expanded network also provide an expanded career opportunity, as the CEPHaS network provided the connections that allowed one participant to gain entry to a PhD programme.

So now I got a PhD... It's through the connection with CEPHaS that I got the PhD, and it's more on statistics, agriculture statistics…. the advert came through the CEPHaS platform. There's this here, and had to apply and then interviews, and that's how I got to that position.

- Research fellow, Zambia, UNZA, Male

3.4.2.2 Inclusive leadership style and structure

One of the most notable areas highlighted by CEPHaS participants about their experience in the CEPHaS project was the projects leadership style and structure. The leadership style and structure of the project were noted as unique as it fostered inclusivity and encouraged the exchange of ideas in a way that was not restricted by hierarchy.

I think CEPHaS had a fairly good balance as far as power dynamics between individuals, I think we have a nice network. We are working well together. I think I see ourselves being in contact for a long time to come. I think we worked as a team, that is the part I liked….The way the project was well organised at home. In my home institution, we had a project team leader, he was encouraging everybody to participate. Himself also, he used to be fully engaged. It was motivating for all the team members to feel part of the team. Also with our UK colleagues, the project leads there, we worked as a unit.
What helped also was, we had at least two trainings where all project staff from all four countries were participating, so we know each other now, like almost all the project staff, we knew each other in a face-to-face setting. Then there were smaller groups…. we would meet with the other colleagues more than once, and then some we would work together in installation of equipment, understanding how the equipment is working. We would work together in writing some reports. The team was well built, so we felt part of the team, we felt like we knew each other. We had a few small social interactions, so it allowed us to relax and to build trust that we can continue to work together for a much longer time.

- Lecturer & researcher, Zambia, UNZA, Female

The structure was seen as something that allowed this inclusivity and was considered from the initiation of the project. The format on which the project was begun took all perspectives into account to ensure functionality and inclusion.

At the start of the project, we had what we called an inception workshop. At that time, all of us were going to work on the project, the young people, like early career researchers, mid-career people like myself, the senior researchers, both from all the countries. We met and worked in detail what would be the deliverables, what would be the working packages and how were we going to achieve this, and we made one big project Gantt chart. From the beginning, every member of the project was involved. We didn't have a top-down thing. Rather, it was like, together, let's achieve this. That was a great experience for me, how to arrange a large project of this nature, interdisciplinary or maybe cross-cultural, many countries, how to arrange it so that we could be able to work together and deliver. For me, that was very good. It was a nice experience that I thought I have valued and I continue to value as I work even to write other proposals, to work with other researchers from other places. It was an excellent experience….Then we had a midterm review, again, we said this is what we said we will do, how are we doing? Again, everybody was supposed to be there, and we all came. We accorded each other. A lot of respect was given to everybody. For me that is valuable and it allowed us to communicate deeply with each other. That's why it's possible actually for me to write to a colleague in Malawi and say, look here, this is what I'm doing. Do you think we can work together? Or colleagues in another place they write to me, can you help us to examine this dissertation? I don't know how you will write that. But I thought I described what I mean by great experience.

- Lecturer & researcher, Zambia, UNZA, Female

Likewise, the attitude and approach of the leadership was positive and supportive. This was the first time that many of these participants had participated in a project of this size and involving this many partners at an international level. Having this positive leadership made a notable impression on many of participants, in a way that encouraged them to be engaged with the work and created a desire for them to emulate this style in their own projects.

I think the leadership. Our team leader, Murray was excellent. Also, the country leads equally were up to the challenge. The leadership was well done. Also the project administration side, I think they were encouraging. That helped very much. Also the senior researchers, I think they believed in the young people, like, you can do it. I think really it was, I don't know whether there's a school for teaching those things. But I think when you experience them, then you learn, like, okay, this is how to lead a large team, this is how to do it better, this is how to motivate people so that they're enthusiastic in the work and so on…Yes. I think it was not like a forcing, it was an encouraging. It was flexible, motivating,

allowing for people to think freely, like your ideas are welcome. That was important. Even when you bring an idea, you see your idea is being debated further and sometimes even taken up. Even trainings, people were allowed, can you suggest which are the trainings you would like to attend. So, people suggest a number of trainings.
- Lecturer & researcher, Zambia, UNZA, Female

Additional aspects of the project structure that were noted were the length of time participants had to work on the project and the frequency of the interactions that the participants had with each other regardless of their location or institute. These key aspects were identified as components that allowed them to form substantial and meaningful working relationships that allowed them to better understand and support one another. The duration, frequency and nature of the interactions were seen as positive and unique to the CEPHaS project compared to other projects participants had been a part of.

Also we were together for much longer, four years. The other project guys, we were together for a shorter time….But if you have many six days in four years, that's a long time then, you begin to know your style. When you say, let's do this, then you say, okay, this one, this is how they operate, this is how it works for him or her

- Lecturer & researcher, Zambia, UNZA, Female

But then this one was a bit different in that it was four years, but maybe every month or every other month there would be something going on and you're constantly in touch with each other even if you're not in one place.

- Lecturer & researcher, Zambia, UNZA, Female

3.4.2.3 Institutional benefits

Many of the areas that participants felt they were benefiting they also felt benefitted the larger institutional as a whole. The larger network across institutes facilitated by the CEPHaS project was seen as beneficial to the institute as it would provide future opportunities for collaboration.

The inter-institutional knowledge exchange that occurred through the CEPHaS project including but not limited to exposure to other systems and financial processes, were seen as components of change and new perspective that would support the institutes' international collaborations in the future. Participants gained exposure to how other cultures and systems function. This was the largest project/grant that these institutes had experienced. It highlighted for partners a need to have processes in place that would align how their institute, partner institutes, and grants function. This perspective was shared by participants across all institutes as a collaboration of this level was seen as novel to participants from each of the institutes.

Participants felt that participation in the CEPHaS project provided reputational enhancement to the institutes involved. It was seen as something that would provide assurance to both funders and other institutes that they were worthy of collaboration on other projects of this magnitude in the future.

Through the CEPHaS project, participants felt that they had gained exposure to other niche areas of science and the interconnectivity of these areas. For many participants, the inclusion of a breadth of niche areas within conservation agriculture were seen as beneficial to both the institutes and the field of conservation agriculture as exposure to these different perspectives and knowledge changed their understanding. Their perspectives when approaching their research and their field was identified as

much more holistic and benefitting from new insights into a multitude of systems outside of their niche areas of expertise.

We just look at the soil physics and that's it, but now with the coming of CEPHaS, it has really broadened our scope to say, it's not really just about the soil, for example.

- Research fellow, Zambia, UNZA, Male

The participant's positive experience with project leadership and community dynamic encouraged participants to want to emulate that leadership style. This was seen by participants as a benefit to the institutes as it would mean they were better placed to support engaging and supportive research projects that would benefit both students and staff.

It's the leadership style I would like to copy. Because for me, I realised that young people really are like a seed of motivation, they just need the right support, like I received the motivation, and also to be involved from the beginning. That was very helpful. For me, I'm a mid-career person, but it was very helpful. …. I try to do it with younger colleagues here. In fact, the approach that I saw with our leaders was more of a mentoring type. I try to do that also with colleagues here…. An example…We have this particular project where once we wrote the proposal, we asked some colleagues to join us. The first thing is we, again, met with them, discussed on what needed to be done and who would do what and then we assigned the tasks. The only thing that was different was that in that particular project we had to recruit the people as our graduate students. I think they were happy the graduate students are not scared to ask. They're not worried to say their opinion, which I think was something that I have learnt that it's okay for people to say what they think because it then builds the whole team. I'm hopeful that I can apply it when the people are not my students, they're just free people.

- Lecturer & researcher, Zambia, UNZA, Female

Lastly, cutting edge research and potential publications coming from the CEPHaS project were seen as components that would lead to increased ranking and visibility of the partner institutes.

As a university also you want to be involved even in cutting edge research, of which some of the research you've been doing is really something which is cutting edge and that has not been done before… as well in that area the university has benefited in this research component. That's why I hope I will be able to write something about it as well and then the university will also benefit publications from it.

- Research assistant & lecturer, Zambia, UNZA, Male

4 Discussion & Recommendations

The survey and interview findings revealed a wide range of reported capacity strengthening benefits resulting from CEPHaS engagement at both an individual and institutional level. Participants consistently expressed their CEPHaS involvement in positive terms with particular praise for the applied 'learn by doing' approach underpinning many of the activities as well as the engaging and highly inclusive leadership. There was evidence that the various trainings and resources provided through CEPHaS were valued, frequently utilised, and often transferred beyond the immediate CEPHaS membership for wider benefit and impact. Some challenges and suggested areas for improvement were reported by participants and potential opportunities to facilitate greater impact were also evident in the data. Our findings therefore suggest that the basic 'template' of the CEPHaS partnership provided a strong basis for research capacity strengthening in Conservation Agriculture, especially at the level of individual researchers, and that this template could be further enhanced in any future iteration of the same or similar programme. Below we outline key strengths of the CEPHaS

partnership that emerged from our study data under the three focal areas of training, resource provision and membership experience as well as specific recommendations for programme strengthening.

4.1 TRAINING

4.1.1 Strengths

- Training topics and content were valued and met perceived needs. Training in the use of 'R' software for statistical computing was especially valued.

- Training topics and content were practical and well aligned with CEPHaS research projects and activities, meaning there were often ready opportunities to apply the new knowledge and skills.

- Interdisciplinary scope of the core training provision.

- Training content was generally perceived as straight forward to understand and pitched at the right level, which was considered introductory – to – intermediate.

- The provision of manuals, SOPS and/or user guides as a complement to training reinforced learning and served as a valued resource for subsequent application and/or transfer of new knowledge and skills.

- The 'hands on', supportive approach to training was appreciated and training providers were considered approachable and accessible.

4.1.2 Recommendations

- The CEPHaS training provision was primarily geared towards specific research- and data analysis-methods. Whilst this training was valued, it was also somewhat limited in scope. Research career development requires a broad array of knowledge and skills as informed by the Vitae framework for researcher development (see Annex 1). Similarly, highly specialised training topics inherently appeal to a smaller pool of researchers/research support staff and have less potential for transfer as compared to more generic research topics (e.g. scientific writing, knowledge translation, principles of project management). Thus, expanding the array of training topics available to CEPHaS members would further accelerate individual career development and would increase the potential 'pool' of training beneficiaries through either direct attendance at a training event or through subsequent knowledge/skills transfer.

- Student supervision/teaching presents as a feasible and potentially fruitful avenue for knowledge/skills transfer when consortia members are drawn from a University setting. Accordingly, any future iteration of CEPHaS could aim to maximise the potential for knowledge/skills transfer via supervision and teaching further, especially at the postgraduate level. For example: content specifically designed to be utilised in teaching programmes could be provided as a complement to training course attendance; the uptake of these resources into teaching curricular could be supported across partner institutions; evidence of knowledge/skills transfer via supervision/teaching could be required of training attendees for whom supervision/teaching is a role responsibility; mentorship/peer review could be provided to develop and present teaching content that draws on CEPHaS training or resources; and sessions designed to enhance core supervision and teaching practices could be included in the broader training provision.

- Acquiring and retaining new knowledge and skills, especially within a research capacity strengthening context, often takes repeated exposure combined with practical application, reflection and feedback. This learning process will often necessitate several structured and flexible learning opportunities over an extended time-period. For example, 'booster' sessions may need to be scheduled at multiple time points following an initial more intensive training event and training attendees may need access to timely and accessible feedback in-between structured events. This extended, multi-pronged approach to training provision was evident in CEPHaS and appreciated by many attendees, although potentially could have been enhanced further.

4.2 Resources

4.2.1 Strengths

- The range of resources provided by CEPHaS were all thought to have addressed existing capacity gaps and were well utilised by all those who had access to them.
- Field and laboratory equipment were especially valued and were thought to provide a multitude of institutional benefits spanning research, teaching and income-generation.
- Resource provision was closely aligned with CEPHaS-supported training topics and applied research projects, consolidating the uptake and transfer of new knowledge and skills.
- The focus on using open-access resources wherever possible (e.g. 'R' software for statistical computing) was considered context appropriate.
- Financial reporting/invoice templates and associated training provided to research support staff improved both project level reporting and broader practices (non-project specific) across the respective CEPHaS partner institutions.

4.2.2 Recommendations

- Survey data indicated access to CEPHaS provided resources was not universal and interview data revealed some concerns re continued access to resources following CEPHaS cessation. Given resource access almost always resulted in use, then ensuring as many people as appropriate have ready access to project provided resources during and after the project lifespan presents as a worthwhile endeavour.
- In line with the aforementioned recommendation, ensure inter-institutional agreements are in place to enable continuity of equipment access in those cases where CEPHaS provided equipment is physically located in one partner institute but used by individuals from other partner institutions or stakeholder organisations. These agreements should include clear expectations re availability and routes of access, terms of use and cost implications (e.g. to support operational and maintenance costs).
- Ensure all institutes and departments have the specific staff who are assigned to equipment maintenance at each institute fully trained before end of project.
- The provision of certain field and laboratory equipment increased the potential for income generation at some partner institutions. Providing the necessary support to ensure partner institutions can maximise these potential income streams during the lifetime of the project may ensure funds to support ongoing operating, maintenance and repair costs of project provided equipment are available over the longer-term. This type of support may be non-scientific in nature (e.g. development and implementation of business plans).

4.3 EXPERIENCE

4.3.1 Strengths

- CEPHaS members were afforded a wide range of research and research capacity strengthening activities, almost all of which were widely utilised.

- The CEPHaS emphasis on applied field work and data analysis aligned well with member interests and were considered important at both individual and institutional levels.

- The CEPHaS leadership style, characterised as collaborative, engaging and highly supportive, was widely appreciated and considered a 'role model' for research leadership.

- All members of CEPHaS, both Northern and Southern, were able to articulate clear and meaningful benefits from belonging to the partnership.

4.3.2 Recommendations

- The study findings suggest the CEPHaS structure was well designed to support capacity strengthening in conservation agriculture among consortia members. Without losing this focus, CEPHaS could potentially facilitate greater institutional impact by including a broader mix of institutional staff in project design stages and resource allocation decisions (e.g. a mix of scientific, management, professional and technical staff). This might include identifying priority institutional barriers to research training, production and transfer prior to launching the scientific research aims of the consortia. This approach is likely to result in more opportunities to leverage project resources for both project-specific and broader institutional gain as occurred to some extent with the project support for finance management practice.

- Networking and collaboration opportunities were considered the most useful aspect of CEPHaS participation at both individual and institutional levels and participant responses suggested a high demand for additional networking opportunities over and above what was already provided. Maximising network opportunities therefore presents as a useful recommendation and by ensuring variety in terms of the focus of networking events and the various stakeholders involved, then their value may be enhanced further.

- Complementary to increasing networking and collaboration opportunities, several study participants also suggested additional community engagement and/or knowledge translation activities would have been beneficial.

- Funding to support Masters or PhD level training was highly desired by CEPHaS members, although was not permitted within the funders stipulations. Where funding stipulations allow, then funding to support postgraduate training could be considered. In the context of grants such as CEPHaS where such funding is not permitted, then efforts could be made to support postgraduate training via creative or complementary means. For example, the grant could cover research and salary costs in support of a PhD or Masters project and tuition fees could be paid privately by the student, waived by the training institution or secured through complementary funding.

- Staff exchanges between CEPHaS partner institutions were proposed by some study participants and could be considered as both an additional capacity strengthening and networking activity.

ANNEX ONE: VITAE PROFESSIONAL DEVELOPMENT FRAMEWORK