FINAL ACTIVITY REPORT

Guidelines on how to complete the activity report are included in italics.

Remember that this report will be made available on your project page on the GBIF website and therefore should not include email addresses, unless you have permission from all mentioned in the report that their email information can be published.

Contents

Project information

Main contact person and role:	Dr. Mushtaq Ahmad
Institution/network/agency affiliation:	Herbarium of Pakistan (ISL), Department of Plant Sciences, Quaid-i-Azam University Islamabad, Pakistan
BIFA Project ID:	BIFA3_47
Project title:	Georeferencing and Mobilization of Plant Species occurrence data from Pakistan
Start date and end date of the reporting period:	1st April 2018-15th April 2019
Country in which the activities take place:	Pakistan

In this report, the collections, all of which are herbaria, are referred to by their international code:

Named as participants. The heads of all these herbaria had agreed to participate in the workshops offered at Islamabad. Some had been provided with barcodes prior to the start of the project.

ISL: Herbarium of Quaid-i-Azam University (given barcodes: lead institution)

SWAT: Herbarium of the University of Swat (had barcodes; funded

participant)
BGH: Herbarium of Malakand University (had barcodes; not funded by this project)
QUETTA: Herbarium of the University of Balochistan (had barcodes; not funded by this project) PMAS: Herbarium of Pir Mehr Ali Shah Arid Agriculture University (not funded by this project).
NAU: Northern Arizona University, participated by supporting the IT development included in the proposal. For administrative reasons, Mary Barkworth participated through NAU.

Not named as participants. These institutions initiated data mobilization after the start of the project.

BANNU: Herbarium of the Government Post Graduate College Bannu (KP; not funded by this project)
PUP: Herbarium of the University of Peshawar (had barcodes; not funded by this project)
RAW: National Herbarium (Part of the Pakistan Agricultural research Council; had barcodes; not funded by this project)
SINDH: Herbarium of the University of Sindh Jamshoro (given barcodes; not funded by this project)

Executive summary

Provide a brief explanation of the project and its implementation, the context and the approach taken for the final evaluation, and a summary of the objectives achieved, lessons learned and conclusions.

The primary objective of this project was to integrate data mobilization into the herbarium in activities. This project had two components: mobilization and georeferencing of records from two herbaria and outreach to other herbaria. At start of 2018, there were 4 Pakistani herbaria providing that, together, were making fewer than 70 records available online via OpenHerbarium. No Pakistani herbarium was a GBIF data provider. Index herbariorum (IH), the world's registry of herbaria, listed 17 Pakistani herbaria but more than half had not updated the information they provided for more than 15 years. At the end of the project, 9 Pakistani herbaria were making 29,251 records available on line via OpenHerbarium; 2 herbaria were GBIF data providers; 21 herbaria were registered in IH; 8 herbaria updated their information in IH in 2018, 3 of them having been registered during the year; 1 more herbarium was added to IH in 2019.

We used a Symbiota-based network, OpenHerbarium, for sharing and displaying records. Data for this report came primarily from monitoring activity in OpenHerbarium. The number of records mobilized was 29,251 but only 17,027 were georeferenced. These numbers reflect those available through OpenHerbarium; Both numbers are below the goals set; in retrospect, the original targets were unrealistically high, partly because it was not appreciated that online data entry is not yet a viable option in Pakistan. The matching IT support was used to fund development of software to address this issue.
Unfortunately, it is still in development; it should be available in May, 2019.

Five herbaria that now regularly provide records to OpenHerbarium include those funded by the project plus 2 that were not named in the proposal. The project funded mobilization in 2 herbaria and, as expected, they provide the vast majority of records now available online but other herbaria are contributing 3477 records of which very few have, as yet, been georeferenced.

Additional workshops are already being planned for 2019, including some on georeferencing. It is anticipated that these will lead to increases in the number of records mobilized and the georeferencing of existing records. The herbaria of Quaid-i-Azam University and the University of Sindh Jamshoro became GBIF data providers in 2018. Other herbaria will be encouraged to apply in the remainder of 2019 once they demonstrate an ongoing commitment to data mobilization.

The reliance on OpenHerbarium makes some aspects of data cleaning difficult because information needed by the GBIF data validator tool is added at the network level when providing data directly to a Symbiota network. Others are best modified by making batch corrections directly on the records. Another set of problems concerns names used in OpenHerbarium but not, as yet, recognized by GBIF. All existing data cleaning issues will be addressed by June 30.

Persuading Pakistani herbaria to update their information in Index herbariorum was unexpectedly difficult. Part of the problem, but only part, was that email information in that resource was either absent or outdated. Personal contact led some herbaria to update their information, but very few to update the table showing how many of different kinds of specimens they had. The updating led to the estimate of total specimens in one herbarium being severely reduced where the estimate for another herbarium was tripled. Efforts to persuade more herbaria to register and/or update their information will continue in 2019.

This project, and discussions at meetings around Pakistan, including many that were not a formal part of the project (for example, the posting for identification keys to KeyBase and posting of published checklists to OpenHerbarium), revealed that there is widespread interest, particularly among young botanists and young herbaria, in becoming part of today's digital biodiversity landscape. Enabling acceleration of the rate at which they can do so, ways must be found to provide learning resources in many related areas in order to assist Pakistan's faculty in addressing the areas that were not included in their own academic training.

The resources should, of course, also be available to students but it is important to support faculty in acquiring the new understanding if they are to take advantage of opportunities to learn new ways of promoting biodiversity knowledge and understanding. This need is encountered in many countries. It is particularly acute in countries where a rapidly expanding population, coupled with a commitment to expanding opportunities at the university and post-graduate levels leads to large class sizes and course- loads. Fortunately, Pakistan has demonstrated recognition of the need for conserving the country's biodiversity and, through support for herbaria, botanical gardens, and workshops, its recognition of the value of biodiversity data mobilization.

Project objectives

This section should include the list of objectives included in your original project proposal, stating for each how far you advanced towards their achievement. Also include any additional objectives that were defined during the implementation of the project. In the event of undexpected challenges prevented you to reach a planned project objective, please provide detailed explanations and indicate how you plan to reach these objectives post project.

1. Mobilize data from 37,000 records, 36,000 from participating herbaria plus 1,000 from other herbaria, prioritizing provinces least well represented in GBIF's Pakistan holdings.

By April 10, only 29,251 records of specimens identified to species had been mobilized, 26,264 from the two funded herbaria, 99 from other herbaria listed as participants, and 2771 from other herbaria. The **major** overestimate came from Barkworth relying too heavily on estimates based on practices and experience in the US and failure to complete an efficient tool for recording verified data offline before the project's completion. Unfortunately, the overestimate impacted all the

other objectives. Additional obstacles included internet access (much better than before but not good enough to permit direct data entry); delays in hiring (partly because positions could not be advertised until the funding had been received); overestimate of the number of hours people would be working (inadequate allowance for standard holidays); and the high proportion of handwritten labels. It was also evident, from working at some of the unfunded herbaria, that poor typing ability may be another significant problem. Many students first have a computer at their disposal when given one through a government award in their first year of university.

To address the internet issue, we reverted to use of a spreadsheet; Lubna (ISL) uploaded data for that institution and Zubeda Zarachi data from SINDH (one of the "other" herbaria). Others send their checklists to Barkworth for upload. An additional problem was that SWAT had not been able to recover as rapidly as hoped from an earthquake prior to the proposal. Consequently, many of its specimens were neither mounted nor in a central location. Both ISL and SWAT hired extra personnel using local funding to address the issue but could not reach the unrealistic target. RAW, another "other" herbarium, had an extra position authorized but, when the government was changed, all unfilled position were cancelled.

Data cleaning has presented some problems. Symbiota has tools for cleaning records with names that do not match a network's nomenclatural backbone and the first and second administrative regions. Lubna used these tools for cleaning data from ISL, updating the second level (provinces) for areas that were incorporated in Khyber Pakhtunkwa shortly after the project began. Barkworth cleaned the records for other herbaria.

Looking at the problems identified by GBIF, the majority reflect failure to complete the datum field for records with lat/lon data. Another problem results from Symbiota's use of "00" for unknown information in tripartite dates. GBIF prefers the event date for such records be placed in the verbatiumeventdate field. We shall address this issue by providing a translation in the verbatimeventdate field. We need both formats because some analyses will be conducted within Symbiota and they will be based on use of the"00" format for unknown information. Initially, there was a problem with people using the 3-number format for the date because one or two spreadsheets came in using both DD-MM-YYYY and MM-DD-YYYY formats. This problem was solved by asked that months be identified by a 3 letter code. Another problem is the mapping of a single elevation number to "maximumelevationinmeters" rather than "minimumelevationinmeters".

The last problem, and one that will be addressed is the presence of completely empty records. All of these issues are best addressed by batch processing, a process that requires access to the back end. Unfortunately, until the database is moved to a different server, which is planned for May, they are almost impossible to take care of at present because of access restrictions imposed by the current host, iDigBio. That is why completion of data cleaning is scheduled for June. We should have checked GBIF's assessment of data quality on a monthly basis.

We had proposed using skeletal data capture as one method of selecting records from under-represented provinces in the data captured but this was one of the objectives that was lost sight of as we struggled to meet the unrealistic target. Looking at the records in OpenHerbarium, those added show a clear emphasis on Khyber Pakhtunkhwa Province (KP; Table 1). The area is not only well known for its floristic diversity, it has long enjoyed better access into its valleys than other part of the country and, for much of its existence, greater political stability in its more accessible areas. All three factors have contributed to making it a favorite collecting area for botanists. Nevertheless, the selection of specimens by herbaria that became GBIF data providers during the project shows a very slight bias towards collections from other provinces.

Table 1. Summary of geographic distribution of records added to OpenHerbarium during the project period. GBIF% is proportion of records for each province coming from one of the two herbaria that became GBIF data providers during the project.

Province	Number of Records	Area (km^2)	Record%	GBIF%	Area%
Azad Jammu & Kashmir	3,016	13,297	10.3%	10.8%	1.52%
Balochistan	2,470	347,190	8.4%	8.0%	39.71%
Gilgit-Baltistan	1,892	64,817	6.5%	6.6%	7.41%
Khyber Pakhtunkhwa	11,116	101,741	38.0%	35.9%	11.64%
Punjab	8,337	205,344	28.5%	30.0%	23.49%
Sindh	2,222	140,914	7.6%	8.0%	16.12%
Islamabad Capital Territory	234	906	0.8%	0.7%	0.10%

Both SINDH and QUETTA became active in data mobilization after the start of the project. SINDH is now a GBIF data provider and QUETTA will be applying shortly. SWAT and RAW did not receive local approval to become GBIF data providers. Active efforts to persuade them to pursue the matter are underway. Other herbaria will be encouraged to become so once they have demonstrated that they see data sharing as a critical component of managing a natural history collection. Two of the herbaria (SINDH and BANNU) were not registered with *Index herbariorum* at the start of the project.

2. Georeference 37,000 records, prioritizing those from poorly represented areas.

17,009 records have been georeferenced. The start of this step was delayed until November, when Barkworth returned to Pakistan. Her return was determined by other commitments so as to maximize the funding available for work in Pakistan. Additional impediments included the lack of freely accessible geographic files for Pakistan's third and fourth administrative levels (district and tehsil). Nelson Rios (Geolocate) had expressed his willingness to integrate them into Geolocate had we been able to obtain them but, despite our best efforts we could not do so. This meant that Geolocate often suggested many locations when searching for a locality. It also became evident that knowledge of an area was critical to georeferencing. The other issue that quickly became apparent was that most specimens, even recently collected records by highly regarded botanists, often have rather imprecise information, for instance, naming a valley where a collection was made but not where in the valley. This problem is not unique to Pakistan. It was a valuable lesson to those attending the workshop – and involved at other locations – in just how precise the verbal description of a locality should be.

3. Build sustainability by engaging at least 10 taxonomists not employed by the project in data mobilization, prioritizing fungi and underrepresented provinces.

This goal has probably been met if one counts those working at the "other" herbaria, two of which (QUETTA and SINDH) are in an underrepresented province. RAW is in the Islamabad Capital Territory and BANNU in Waziristan, a poorly explored portion of Khyber Pakhtunkwa Province. In general, all those engaged in data capture are either graduate students in plant taxonomy and/or plant conservation. One mycologist created a record in *Index herbariorum* for the fungarium of Islamia College (ICFP) but, on return to his institution, his other responsibilities prevented him making any progress in data mobilization. Other institutions have expressed interest, including an algal collection, but no progress has yet been made in making them data providers. Efforts to do so will continue in 2019.

4. Contact all herbaria in Pakistan, both registered and unregistered, to obtain current information on their holdings and persuade them to share the information with *Index herbariorum*

A survey was sent out to those in charge of all registered herbaria in September. No responses were received. Through personal contact made during 2018 at meetings both before and after the start of the project, 3 collections were persuaded to register with *Index herbariorum* and 8

to update their information in that repository but only 4 completed the table showing how many specimens they had of different kinds and how many were databased. A fourth herbarium, BANNU, was added on April 10, 2019. Given the lack of success in persuading registered herbaria to update their information in *Index herbariorum*, we did not attempt to reach out to the unregistered herbaria. The report is based on information in Index herbariorum.

5. Develop data papers on the Flora of Pakistan and the Flora of District Swat.

Barkworth (NAU) has started work (as lead author) on a data paper about the development of electronic floristic resources for Pakistan. It is designed for publication in Taxon, a journal that reaches taxonomically oriented botanists that, it is thought that this will be an appropriate venue for stimulating greater interest in data mobilization by herbaria and botanists through the world. She will use what she has learned from publishing in Phytokeys to stimulate interest. It will include a synopsis of available records from all Pakistan's provinces.

Zahid Ullah (SWAT) has started work on data paper concerning development of a multifaceted checklist for District Swat. His goal is to have it ready for submission in October 2019, after completion of the field season and transfer of the herbarium to its new facility.

Activities

Please indicate the status of the activities as outlined in the project proposal, at the time of final reporting. The table below should be completed in the same way as in the full proposal but should include information and updates on the status of each activity.

In the event of unexpected delay please provide detailed explanatory notes and indicate planned completion date after the end of the project. Add as many rows as needed.

In the event of any additional activities having being completed during the implementation of the project, please add rows as required.

Description of activity	**Partners involved**	**Contribution of activity to goals listed in table 4.3**	**Status of activity as of final reporting Completed? Yes/No**	**Explanatory notes, inc. planned completion date if necessary**	**Source(s) of verification**
Digitizing and publishing georeferenced species occurrence data based on specimens held in Asian collections					
Develop pdfs on fields used for capturing data, including georeference data, in Symbiota.	NAU (Barkworth)	Increase quality of data capture and encourage better field notes when collecting.	Yes	This is a long document. It is being broken up into smaller documents. These may be used for YouTube videos but it is a useful to have a print (or pdf) copy available to consult after a workshop.	Entering data into Symbiota
Compiling inventories of biodiversity data holdings (for example, by implementing metadata catalogues)					

Ask herbaria registered with Index herbariorum for information required to update their records in that resource.	ISL, SWAT	Essential for goal 4.	Yes but …	No herbarium responded to the survey. In retrospect, should have kept it more factual and avoided all questions on budget. Several records were updated, but only in response to personal contact. Will continue efforts in 2019.	Survey sent. See also entries for Pakistan in Index herbariorum. A link to a summary report, containing links to entries in Index herbariorum, is included in this report.
Preparing data papers					
Data paper on Pakistan: Review data, family by family, from Flora of Pakistan, revising nomenclature where appropriate.	NAU (Lead) ISL, SWAT, plus others	A useful contribution to the proposed data paper	No	Much, but not all, of the nomenclatural backbone of OpenHerbarium has been improved, with reasons being given for a decision concerning synonymy (usually World Flora Online). The activity is ongoing. Involving Pakistani botanists is not feasible as few have much understanding of nomenclature, A less ambitious data paper will be started in May.	Resources being developed include keys from Fl. Pakistan. These link terminal taxa to taxon pages in OpenHerbarium but most pages are currently empty. An example of one that is not is available here. Currently, seeing reasons for taxonomic decisions requires editorial privileges. This will be changed in Symbiota2. Unfortunately, at present, only nomenclatural editors can see the reason for a treatment. Barkworth has requested that, in Symbiota2 (which is in development), the information be visible to all.

Compare species from checklists with those in Fl. Pakistan and coming from herbaria.	ISL, NAU, SWAT	Part of data paper	No	A less ambitious data paper will be completed by the end of the September.	
Swat data paper	SWAT (lead), NAU, ISLA	Planned data paper	No	A checklist has been developed from various sources; it contains 1643 species but, at present, 1222 are without vouchers and, based on records in OpenHerbarium, another 229 are documented from the district. Barkworth and Zahid Ullah will collaborate in making it a more accurate statement of species in the district.	http://openherbarium.org/portal/checklists/checklist.php?cl=13&pid=7 Note: Checklists were not part of the proposal and are not documented (yet) according to GBIF requirements. They can be used for education and outreach at multiple levels – as well as research.
Offer to work with Pakistanis who have published checklists to make them available as data papers.	NAU, SWAT, ISL	Potential data papers that would lead to greater appreciation of advantages of digitization.	Yes – but not successful. Also ongoing.	People expressed interest in having someone else put up their checklist, but not at doing so themselves, possibly because they are unfamiliar with the concept and do not think it would benefit their evaluation.	Will continue to encourage publication of checklists, plus enrichment of their underlying content by, for example, quantitative comparisons of species and clade diversity and richness.

Hold blended workshop on value of data mobilization	NAU, ISL, SWAT	Develop sustainability in data mobilization and sharing	Yes and no.	After looking at specimens in a few non-participant herbara, decided that the greatest need was for blended workshop on making high quality herbarium specimens. Attempted to give one but failed to provide instructions for last phase. Completion was scheduled for April 30. It has been delayed.	Will announce via FaceBook and Twitter when available.
Miscellaneous additional activities					
Redesign web site to make it easier to locate resources for and from Pakistan.	NAU	Increase visibility of Pakistan data and collections sharing their data.	Done	Data from Pakistan is now easier to locate and some problems with the initial institution have been addressed. Many functions are hard to find. Symbiota2, a separate project, will address this aspect in 2020.	http://Openherbarium.org/portal/collections/

Enabling offline, verified data entry	NAU	Make provision of high quality data easier and more efficient.	No, still in progress.	Documentation is being written. It will enable easy installation on a local computer and will include tables for checking scientific names and administrative units.	Paper will be released when it is released. https://github.com/sylviakinosian/spindle
Post keys from Fl. Pakistan to OpenHerbarium, linking terminal taxa to pages generated by OpenHerbarium	NAU	Make it easier to use resources, and see value of mobilized, shared, data.		395 keys are now online. A few have been modified to reflect current taxonomy. They have been used on FaceBook to suggest features people should look at when asking for an identification.	Keys are at https://keybase.rbg.vic.gov.au/projects/show/34 Unfortunately, at present most pages are empty.

Deliverables

This section should summarize the project deliverables completed by the final reporting date, with a description of the associated outputs. Please highlight any changes from the original plans provided in the full project proposal.

In the event of unexpected delay, please provide detailed explanatory notes and indicate planned completion date. Add as many rows as needed.

In the event of any additional deliverables having being completed during the implementation of the project, please add rows as required.

a. Data

Details of datasets mobilized and/or pending mobilization as an outcome of the project: Please use list from mid-term report and update this as at final reporting.

If the dataset is not yet published, please indicate it as "not published" and provide a detailed explanation and expected date of publication. Add rows as required.

Title of dataset	Taxonomic/ geographic scope	Approximate number of records (specimens)	Current format (e.g. undigitized, digitized)	Status of dataset: Published/not published – inc. date/expected date of publication	Explanatory notes	DOI or URL
ISL - Quaid-i-Azam University	Vascular plants/ Pakistan	29000/29000	Published: 26,309/16,695 To Do: 2,700/13,305	Published to GBIF: 26309/16695	For reasons explained above, target was not reach but the herbarium will continue to add records.	GBIF.org (24 April 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.njpegt
SWAT – University of Swat	Vascular plants/ Pakistan	6000/6000	Published: 902/203 To do: 5098/5797	Cannot predict completion date. Published records are available to OpenHerbarium	Explained under goals	OpenHerbarium: http://openherbarium.org/portal/collections/misc/collprofiles.php?collid=33

SINDH – University of Sindh Jamshoro	Vascular plants/ Pakistan	0/0	Published: 2168/44 Number published is of non-empty records.	Committed to data sharing as a result of pre - project meeting in March (see calendar of activities); not included in proposal. Empty records will be deleted by June 30; georeferencing will be started in fall 2019.	Funding was from grant by Pakistan's Higher Education Foundation for development of herbarium and botanic garden.	GBIF.org (24 April 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.rsqqj9
QUETTA – University of Balochistan	Vascular plants/ Pakistan	1000/1000	Published: 96/85 To do: 904/915	Cannot predict completion date.	Funding was from grant by Pakistan's National Science Foundation for herbarium and botanic garden. There was a breakdown concerning QUETTA. It is being addressed.	GBIF.org (24 April 2019) GBIF Occurrence Download https://doi.org/10.15468/dl.nkqwmp

Other herbaria (RAW – Pakistan Agricultural Research Council) and BANNU (Government Post Graduate College Bannu) are on the way to becoming data providers; PUP and BGH will probably do so towards the end of 2019.	Vascular plants/ Pakistan	1000/1000	**RAW**: Published 604/19 **PUP** Published 219/58 **BANNU**: 11/0 **BGH** Published 3/0 **TOTALS** *excluding* SINDH 837/77 *Including* SINDH 3006/21	Target for published records has been met, thanks to SINDH (see above); it is anticipated that the georeferencing goal will be met in 2019 and that RAW, BANNU, PUP, and BGH will become GBIF data providers by December 2019. BANNU committed to data sharing as a result of pre - project meeting in March (see calendar of activities); it was not included in proposal.	BANNU approached Barkworth about sharing records in March, 2019. PUP and BGH are expected to make much greater progress in 2019 as a result of a workshop being planned for 2019 – funding is being requested from Pakistan's Higher Education Council. The meeting is being sponsored by the universities of Peshawar and Malakand.	Records from all four herbaria are available in OpenHerbarium: **RAW** http://openherbarium.org/portal/collections/misc/collprofiles.php?collid=45 **PUP** http://openherbarium.org/portal/collections/misc/collprofiles.php?collid=7 **BANNU** http://openherbarium.org/portal/collections/misc/collprofiles.php?collid=60 **BGH** http://openherbarium.org/portal/collections/misc/collprofiles.php?collid=46

b. Other deliverables

Describe other deliverables (e.g. publication of data papers, catalogues, reports etc.). produced and/or planned to be produced as a post-project deliverable. Please provide indicative dates/estimated time for completion for planned post-project deliverables.

Please provide links in the sources of verification. Attachments should be provided in the Annex.

Name and type of deliverable	Status of deliverable Published/not published – inc. date/expected date of publication or estimation of time for completion	Explanatory notes	Source(s) of verification
Data paper on Flora of Pakistan	Not published but a less ambitious paper will be submitted before June 30, 2019	The goal was overly ambitious.	Proposed publisher: TAXON.
Data paper and checklist for Swat	Not published; target October 2019.	The goal was overly unrealistic given the physical challenges involved (lack of accommodation for herbarium; need to plan for moving).	Proposed publisher: Pakistan Journal of Botany or Pensoft. Checklist (under active revision): http://openherbarium.org/portal/checklists/checklist.php?cl=13&pid=7

Checklists for different regions, with notes on medicinal use	8 checklists have been published but not those proposed. Checklists for Khyber Pakhtunkhwa, Balochistan, and Sindh have been initiated. They draw from checklists for regions within the relevant province.	Those who have prepared checklists are not yet convinced that there would be added value, including personal value, from making them web accessible. The one herbarium that does appreciate this is BANNU but effective contact was not made with them until April 2019. Most of the checklists posted were from recently published articles but two, one for Karachi and the other for Balochistan) are based on old floristic works. They are being posted as part of a collaboration between Barkworth and Drs. Mudassir Asrar (QUETTA) and Rabia Memon (SINDH), both of whom have expressed interest in developing provincial resources.	Pakistan, Azad Jammu & Kashmir, District Kotli: http://openherbarium.org/portal/checklists/checklist.php?cl=28&pid=7 Pakistan, Azad Jammu & Kashmir, District Muzaffarabad: http://openherbarium.org/portal/checklists/checklist.php?cl=137&pid=7 Pakistan, Balochistan: http://openherbarium.org/portal/checklists/checklist.php?cl=141&pid=7 Pakistan, Khyber Pakhtunkhwa, District D.I. Khan, Sheikh Buddin National Park http://openherbarium.org/portal/checklists/checklist.php?cl=134&pid=7 Pakistan, Khyber Pakhtunkhwa, District Lower Dir: http://openherbarium.org/portal/checklists/checklist.php?cl=93&pid=7 Pakistan, Khyber Pakhtunkhwa, District Swat: http://openherbarium.org/portal/checklists/checklist.php?cl=13&pid=7 Pakistan, Khyber Pakhtunkhwa, District Swat, Kabal Valley: http://openherbarium.org/portal/checklists/checklist.php?cl=29&pid=7 Pakistan, Khyber Pakhtunkhwa, Haripur Hazara: http://openherbarium.org/portal/checklists/checklist.php?cl=27&pid=7 Pakistan, Sindh, Karachi http://openherbarium.org/portal/checklists/checklist.php?cl=140&pid=7

Publish report on status of Pakistani herbaria	Not started.	The major problem is our inability to obtain responses to our inquiries from those in charge of Pakistan's herbaria – and to prepare a constructive report for an appropriate entity in Pakistan.	Status of Pakistani herbaria April 24, 2019.
Submission of report at TDWG 2018 and TDWG 2019	Done	Barkworth and Cobb made a presentation on embedding data biodiversity data sharing at TDWG2018 that reflected work in both Pakistan and Somaliland. A multi-authored abstract on "Developing Digital Botanical Resources for Pakistan" is under revision for TDWG2019.	TDWG 2018: DOI: 10.3897/biss.2.26262 TDWG 2019: Being rewritten for inclusion in symposium on increasing capacity sponsored by GBIF.

Commitment of additional herbaria to data mobilization.	This has taken place and it is anticipated that more herbaria will do so in 2019. All will be invited to participate through OpenHerbarium because this makes doing so simple and will, eventually, show the benefits of collaboration.	Personal connections are important. Presentations at meetings in Pakistan (see below) have led to several expressions of interest.	See links on pp. 14-15 to data sets for SINDH, RAW, PUP, BANNU, and BGH above.

Submission of proposals to HEC for digitization of fungal collections and additional plant collections.	BANNU has been funded for development of a herbarium and its curator sees data mobilization via OpenHerbarium and GBIF as highly desirable. Similarly, SINDH and QUETTA received funding (QUETTA before the start of this project) for their herbaria and are pursuing data mobilization with those funds. Unsuccessful attempts were made to persuade one fungal and one algal herbarium to start work towards a proposal. The efforts will be continued.	HEC funded presentation and workshop at the University of Jamshoro Sindh in December; University of Peshawar funded presentation and workshop at the University of Peshawar in November. So far as is known, no proposals have been submitted for funding non-vascular plant collections.	

Calendar of activities

The calendar should be completed in the same way as in the Full Project Proposal (4.6) but should include any changes. Please provide reasons for any changes in the Notes column in the table below.

Dates	Activity	Lead partner	Notes
Mar 23-26 Not part of project but	Presentation and workshop Pakistan Botanical Society Meeting Had major impact on project: 1. Reason for Barkworth's presence in Pakistan at start of project. 2. Met Zahid Ullah (SWAT), Rabia Memon (SINDH), Shahid Jamil (BANNU), and Ishtiaq Ahmad (registered new herbarium). Also many others mentioned in this report. Used, and had participants use, online access to OpenHerbarium during workshop.	NAU - Barkworth	Workshop schedule clashed with presentation schedule so it became, in effect, 3 separate workshops.
April 7-8	Introductory workshop at ISL[a]	ISL (Mushtaq Ahmad) for organization; NAU (Barkworth) for presentation.	Two individuals, one each from Islamia College and the University of Peshawar, who had assisted with pre-starting date workshops in Peshawar and Chitral helped at this workshop. BGH and PMAS failed to attend; QUETTA was not represented by person funded to make QUETTA records available and he did not contact her or Barkworth for assistance.

June 2018	Attendance of project team member at BIFA Capacity Enhancement Workshop[b]	Mushtaq Ahmad (ISL) appointed Lubna to represent ISL. Barkworth attended as a mentor.	Lubna was unable to complete class within time given because it required internet which she did not have for the designated time period. Barkworth could not set aside the time to do so.
Each month	Monitoring of progress[c]	NAU (Barkworth)	The monitoring occurred more frequently towards the end of the project.
Jul 21-25	Botanical Society of America	NAU (Barkworth)	
Aug-Sept	Contact herbaria concerning their holdings	SWAT (Zahid Ullah)	
Aug 27	Presentation at TDWG 2018	NAU (Barkworth)	Also learned more about amending data to conform to GBIF standards, biggest problem being the data format used
Nov 26-27	Workshop at ISL on georeferencing[d]	Mary Barkworth, Mushtaq Ahmad	Mary had attended for one day due to delayed flight
Nov, Dec	Submit data papers on Flora of District Swat and on resources electronic data resources for Pakistan	SWAT (Zahid Ullah lead); Pakistan (Barkworth lead)	Postponed
Nov 29-Dec 1 (not part of proposal)	Blended workshop at University of Peshawar[e]	NAU (Barkworth)	Instructions for follow up assignment not completed.
Dec 3-4	Workshop at the University of Sindh Jamshoro, including collecting trip for SINDH employees.	Mary Barkworth	Had to postpone one day because of flight cancellation.

General explanatory notes

a. The timing was determined by Barkworth's pre-existing plans for being in Pakistan, a considerable cost saving.
b. Barkworth also participated in the workshop, the intention being that she would be a mentor but her lack of familiarity with much of the material was frustrating for all.
c. Email was used to determine the impediments to anticipated progress. Unfortunately, understanding an impediment is sometimes easier than being able to address it. Both ISL and SWAT hired extra personnel, using local funds, in an attempt to meet the stated goals.
d. The schedule originally called for a 2 day meeting, starting Nov 24. A short connection in Karachi put that in jeopardy and problems on campus precluded meeting over the weekend Nov 26-

27. The basics were covered, and some handouts provided. Probably the most valuable aspect was having a collector present who could point out where the specimens were collected and comparing that information with what would be inferred from the label.

e. Objectives changed after reviewing specimens and realization that what was planned as workshop was organized as a presentation. Topic became "Preparing good specimens starts in the field". Barkworth promised to make information on what constitutes a high-quality specimen available on line. Will be done by May 15.

f. The flight booked was cancelled, which meant delaying the workshop which caused some problems because it meant that it overlapped with a local holiday and extended into the following work week. On the other hand, having few people present for the field work part of the meeting, which was held on Monday, was beneficial.

Project communications and visibility

Describe the way the results of your project have been and will continue to be communicated and shared with the project stakeholders and broader GBIF community. Please also review the page describing your project available from http://www.gbif.org/programme/bifa . Highlight any additional documents, events, news items or links that you would like to add to your page and provide links/attachment in the Annex.

Information was posted at irregular intervals to the FaceBook page for the Pakistan Society of Plant Taxonomists established by Zahid Ullah (SWAT) before the start of the project (*https://www.facebook.com/groups/223345931473211/*). It is probably the most effective mechanism for reaching botanists in Pakistan.

We had planned to organize a series of presentations at the 2019 meeting of the Pakistan Botanical Society that was to be held in Lahore. In late December, we were informed that the meeting would not take place until 2020.

Barkworth included information on what was being accomplished in her presentations at both the University of Peshawar and the University of Sindh Jamshoro.

Final evaluation findings and conclusions

This section of the report should cover for example:

- *An evaluation of the project activities and their outputs/deliverables*
- *An assessment of the overall outcomes, impacts of the project and how it contributes to the overall objective of the BIFA programme*
- *Comments on the project implementation and completion, and its efficiency and effectiveness, strength and weaknesses etc.*
- *Any feedback on the project's relevance from the partners and stakeholders*
- *Indications and reasons for any changes which have been made to the project's original plans, and actions to follow-up*
- *The management arrangements for the project, including support from the GBIF Secretariat*
- *Areas of success to build on, after the project's implementation period*
- *Conclusions from your experience during the implementation of the project*

Notable progress was made in mobilizing records from Pakistani herbaria and, importantly, making data sharing a concept that most Pakistani botanists are now aware of although most are still skeptical of its value. This last is not unreasonable because, for many of them, internet access is still slow. Cell phone access

is better. Fortunately, Symbiota is in the process of being redesigned into Symbiota2, as part of which its interface will be redesigned and made responsive. Another reason that the value of data sharing is not appreciated is that it is not perceived as something that will enhance a botanist's resumé nor the reputation of an institution. This will change with time. On the plus side, there is widespread interest, particularly among the younger herbaria and younger botanists in becoming part of the digital scientific world. This is reflect in the addition of two herbaria that were not mentioned in the proposal, SINDH and BANNU, leaders of which met Barkworth at the Pakistan Botanical Society meetings immediately preceding the start of the project.

The project, and associated activities, have also helped start a discussion of the digital resources needed to promote better floristic research in Pakistan. Such resources should include not just georeferenced specimen records but also, for example, resources for understanding the terms used in keys, preferably in multiple languages and drawing on examples from common species in the area. This will help Pakistan's students make use of the keys and descriptions in the Flora of Pakistan. There is also a need for nomenclatural resources so that there is better understanding of the reasons names are changed. The project has also provided resources that can be used in seeking federal and provincial support for the process of developing a strong electronic infrastructure for biodiversity studies in Pakistan, one that includes access to geographic files for political units, weather data, and geology.

Sustainability plans

Please provide a description of how the partners involved will build on the results of this project in their future work. This could include future collaborative activities, such as plans to complete any unfinished project activities and how the future impact of the project could be monitored and/or measured.

Collaborative projects: Zahid Ullah and Mary Barkworth are committed to leading preparation of data papers relating to information about the plants of District Swat and Pakistan, respectively. The one for Pakistan will also involve several individuals at other institutions.

We shall also, as individuals, continue to promote specimen data mobilization (including georeferencing) in Pakistan. Barkworth is already working with PUP and BGH on a workshop in Malakand and assisted Dr. Rabia Memon (SINDH) in an application to work at the St. Louis Botanical Garden, St Louis, during the 2019-2020 academic year. If successful, they will spend some time there discussing expansion of data mobilization and use of mobilized data at SINDH. She will also continue sharing updates and making more resources available on line. Zahid and Mushtaq will continue to work on specimens in their own herbaria.

Barkworth will, because her obligations to the US National Science Foundation funded Symbiota 2 project, place more emphasis on placing instructional materials online. It seems, however, that for such resources to be useful, there must a core of people within an interacting group that are engaged in the activities involved. She will continue to work with a range of individuals in Pakistan, including reaching out to more of the federal herbaria. One goal in doing so is to persuade Pakistan to consider becoming a full member of GBIF.

The financial sustainability of data mobilization in any country, including Pakistan, depends on constantly emphasizing its value, including its practical value. This also means making provision of accessible specimen records a critical ingredient of respected research paper, whether floristic,

phylogenetic, or agricultural.

Symbiota itself, or rather Symbiota2, continues to rely on research funding for its maintenance but this research must provide new capabilities. Areas that would benefit many Pakistani herbaria are developing modules designed for botanical gardens, surveys, and education – including elementary education and education of villagers relying on collecting will-grown materials for the burgeoning medicinal and aromatic plant market (though it is better, from a conservation point of view, to promote cultivation of the relevant species. The current Symbiota2 project will also have tools that will make it easier for collectors to convert their collections, field notes, and field images to valuable and accessible online resources.

Recommendations and lessons learned

This section should describe your experiences that could help in designing and implementing biodiversity mobilization projects more effectively, including the best practices to adopt and the pitfalls to avoid.

Biodiversity mobilization should be seen as one part of an integrated biodiversity landscape that starts with well-documented field work. The length of time it takes to process specimens is a major deterrent to collecting. For that reason, making options for shortening the time required are in development, both by individual graduate students and funded projects. They need to be encouraged, including the development of resources suited to use by local people. What is needed will vary from country to country.

Much became evident from this project. These include the advantages of being able to type efficiently; the need for more realistic understanding of the financial cost of maintaining herbaria, particular research herbaria; better understanding of why specimens are important – and the resulting requirements concerning the preserved material and its documentation.

Annex – Sources of verification

Sources of verification are for example links to relevant digital documents, news/newsletters, brochures, copies of agreements with data holding institutions, workshop related documents, pictures, etc.

These links are organized according to the calendar of activities. They are to presentations, handouts, pictures, and videos.

Preproject: Valuable connections were made at these meetings which were scheduled before the project was funded.

Mar 23-26: Presentation at meeting of Pakistan Botanical Society; handout (on flashdrive) and the fun part.

Mar 29-Apr 2: University of Chitral (same as one used for University of Peshawar):; Mary Barkworth with Dr. Rabia Memon; television broadcast about the conference University of Chitral.

Activity 1. Create pdfs on Entering Data into OpenHerbarium(PK) explaining fields used for capturing data, including georeference data, in Symbiota.

Activity 2. Workshop on entering data into Symbiota. Complete data entry form. Handout outs; Attendance; Feedback.

Monitoring of progress - format used at end of project. Red - changes since previous report (no more than 1 month earlier, sometimes only 1 week earlier).

Jul 21-25 Botanical Society of America: Poster about SPINDLE; see also GitHub; presentation on Symbiota2

Activity 3: Identify and determine status of Pakistani herbaria. Survey sent. Should have kept to straight forward questions - with none about budgets. See links on page 17 for status of individual registered herbaria. Summary developed April 14, 2019.

Aug 27 Presentation at TDWG. Embedding Data Sharing in Biodiversity Research. Somewhat related – Symbiota2.

Activity 4. Georeferencing workshop. Overview; concepts and localities; best practices (all three provided via flash drive so could be copied); attendance; feedback.

Presentation University of Peshawar; in herbarium 1, 2.

Presentation and field trip, 2; University of Sindh Jamshoro

Summary of accomplishments: at end of project.

All above links are to resources on web page of resources developed in connection with the project plus pictures etc.

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Signed on behalf of the project partners Date

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