

Research Application Summary

Pharm-BioTechnology and Traditional Medicine Centre: An Eastern and Southern Africa Higher Education Centers of Excellence Project at Mbarara University of Science and Technology

Tolo, C.U.¹, Ogwang, P.E.² & Weisheit, A.³

¹Pharm-Bio Technology and Traditional Medicine Centre (PHARMBIOTRAC), Department of Biology, Faculty of Science, Mbarara University of Science & Technology (MUST), P. O. Box 1410, Mbarara, Uganda

²Pharm-Bio Technology and Traditional Medicine Centre (PHARMBIOTRAC), Department of Pharmacy and Pharmaceutical Sciences, Faculty of Medicine (MUST), P. O. Box 1410, Mbarara, Uganda

³Pharm-Bio Technology and Traditional Medicine Centre (PHARMBIOTRAC), Mbarara University of Science & Technology (MUST), P. O. Box 1410, Mbarara, Uganda

Corresponding author: tolocas@must.ac.ug

Abstract

A regional approach to higher education in Africa offers the best way to build and sustain excellence in higher education in African economies, and to develop the human resources required to address key development challenges facing Africa. One of the key development challenges facing Africa is a low life expectancy and productivity compared to in other continents, majorly due to a high burden of both communicable and non communicable diseases, a situation made worse by inadequate yet expensive good quality drugs not easily accessed by the population. Yet Africa has a rich biodiversity that forms the continent's natural wealth on which its social, cultural and economic systems are based; and this is particularly true for eastern and southern African regions. Traditional Medicine (TM) and Traditional Medicine Knowledge (TMK) systems form part of this wealth, but has not been science driven to improve quality of life and productivity in the region. Apart from TM, African biodiversity has enormous potential to produce modern drugs such as high value biopharmaceuticals but it has not been scientifically explored and developed either. Biopharmaceuticals are therapeutics derived from biological or living organisms through application of pharm-biotechnology. While several other factors may be contributing to under-exploitation of TM, TMK systems and low application of pharm-biotechnology to biodiversity in Africa, the key factor remains largely inadequate number of scientists specialized in TM and pharm-biotechnology. To respond to this gap, Mbarara University of Science and Technology (MUST) through the World Bank's African Centres of Excellence (ACE) initiative is creating, in the region, a unique framework by establishing "*Pharm-Biotechnology and Traditional Medicine Centre*" (PHARMBIOTRAC) in order to build capacity in the region to train and raise a critical mass of specialized and skilled human capital that can use multidisciplinary and transdisciplinary approach to advance traditional medicine and pharm-

biotechnology. The specialists to be produced at this centre will be experts in critical areas including; reverse metabolomics, genomics and proteomics (molecular characterization, structural elucidation and modification of drug molecules or drug receptors) with potential to spur drug discovery; and specialists in production and use of high value biopharmaceuticals and TM products for uptake by pharmaceutical and herbal medicines industries in the region and beyond. Through linking research and education to industry, the research outputs and the graduates of PHARMBIOTRAC will be absorbed by private sector industry to mass produce high value science driven TM products and biopharmaceuticals highly needed for disease control and prevention worldwide.

Key words: ACE II, Centres of Excellence, Eastern and Southern Africa, Mbarara University of Science and Technology, Pharm-Bio Technology, Traditional Medicine

Résumé

Une approche régionale de l'enseignement supérieur en Afrique offre la meilleure façon de construire et de maintenir l'excellence dans l'enseignement supérieur dans les économies africaines, et de développer les ressources humaines nécessaires pour relever les défis majeurs du développement de l'Afrique. L'un des défis majeurs de développement auxquels l'Afrique faire face est une faible espérance de vie et la productivité par rapport à d'autres continents, principalement due au poids élevée des maladies transmissibles et non transmissibles, une situation aggravée encore par des médicaments inadéquats, très chers et pas facilement accessibles à la population. Pourtant, l'Afrique a une riche biodiversité qui constitue la richesse naturelle du continent sur lequel ses systèmes sociaux, culturels et économiques sont fondés; et ceci est particulièrement vrai pour les régions d'Afrique orientale et australe. Les systèmes de médecine traditionnelle (TM) et des connaissances en médecine traditionnelle (TMK) font partie de cette richesse, mais n'ont pas été un enjeu scientifique pour améliorer la qualité de vie et la productivité dans la région. En dehors de TM, la biodiversité africaine a un énorme potentiel pour produire des médicaments modernes tels que les produits biopharmaceutiques de grande valeur, mais ceci n'a pas été aussi scientifiquement étudié et développé. Biopharmaceuticals sont des produits thérapeutiques dérivés d'organismes biologiques ou vivant par l'application des pharm-biotechnologie. Bien que plusieurs autres facteurs pourraient contribuer à la sous-exploitation des systèmes TM et TMK et une faible application de pharm-biotechnologie pour la biodiversité en Afrique, le facteur clé reste le nombre largement insuffisant de scientifiques spécialisés dans TM et pharm-biotechnologie. Pour répondre à cet besoin, l'Université de la science et de la technologie de Mbarara (MUST) par le biais de l'initiative des centres d'excellence en Afrique de la Banque mondiale (ACE) crée, dans la région, un cadre unique, en établissant "Pharm-biotechnologie et Centre de médecine traditionnelle" (PHARMBIOTRAC) afin de renforcer les capacités de la région à former et élever une masse critique de capital humain spécialisé et qualifié qui peut utiliser l'approche multidisciplinaire et transdisciplinaire pour faire avancer la médecine traditionnelle et la pharm-biotechnologie. Les spécialistes qui seront produits dans ce centre seront des experts dans des domaines critiques, y compris; la génomique et la protéomique (caractérisation moléculaire, élucidation de la structure et la modification des molécules de médicaments ou de récepteurs de médicaments) avec un

potentiel pour stimuler la découverte de médicaments; et les spécialistes en production et utilisation de produits biopharmaceutiques à haute valeur ajoutée et des produits TM pour l'absorption par les industries de médicaments pharmaceutiques dans la région et au-delà. En associant la recherche et l'éducation à l'industrie, les résultats de la recherche et les diplômés de PHARMBIOTRAC seront absorbés par l'industrie du secteur privé à produire en masse des produits issues des technologies du TM et des produits biopharmaceutiques très nécessaires pour le contrôle et la prévention des maladies dans le monde

Mots clés: ACE II, centres d'excellence, Afrique orientale et australe, Université des Sciences et de la technologie de Mbarara, Pharm-Biotechnologie, médecine traditionnelle

Background

Africa has a rich biodiversity that forms the continent's natural wealth on which its social, cultural and economic systems are largely based, yet Africa still has a low life expectancy and economic productivity compared to other continents. This is majorly due to a high burden of infectious diseases such as malaria, HIV, tuberculosis etc. and now also rising cases of non-communicable diseases, hence causing a dual health challenge. The non-communicable diseases such as cancers, diabetes, hypertension, stroke, obesity, and chronic respiratory disease are becoming rampant killer diseases and are predicted to overtake infectious diseases in the near future. This situation is made worse by inadequate yet expensive drugs and even where drugs are available, counterfeit drugs continue to flood the market with up to 35% of antimalarial drugs accessed by the population reported as being *counterfeit* products. However, for ages, Traditional Medicine (TM) and Traditional Medicine Knowledge (TMK) systems have formed part of Africa's wealth, but have not been science driven to improve quality of life and productivity in the region (e.g. Ogwang *et al.*, 2008; Weathers *et al.*, 2014; Ogwang *et al.*, 2015). Apart from TM and TMK, Africa's biodiversity has enormous potential to produce modern drugs such as high value biopharmaceuticals but it has not been scientifically explored widely and developed. In addition, very little work has been done in clinical validation of TM and TMK. The lack of clinical evidence creates a huge knowledge gap that limits use by biomedical health practitioners. This in turn limits potential investment in TM related drug discovery and products development by the private industry. While several other factors may be contributing to under-exploitation of TM and TMK systems and low application of pharm-biotechnology in Africa, the key factors remain inadequate number of scientists specialized in TM and pharm-biotechnology, lack of multi-disciplinary and trans-disciplinary research teams, lack of appropriate equipment and skills, lack of specialized training in the region to raise the critical mass of scientists in TM and pharm-biotechnology, poor linkages with private sector and non-involvement of TMK holders in the training and research programs.

To address the above challenges, Mbarara University of Science and Technology (MUST) through the World Bank's African Centers of Excellence (ACE) initiative is creating, in the region, a unique framework to produce specialized and highly skilled graduates (Goddard and Chatterton, 2003) that will exploit the rich flora and fauna to develop high value science driven TM products and biopharmaceuticals to address not only development challenges of

Africa but also preserving the local biodiversity. The ACE will create a conducive and enabling environment for curriculum review and development to create specialization on science driven TM and pharm-biotechnology training, research and product development at postgraduate level. Equipped with state-of-the-art equipment, Pharm-Bio Technology and Traditional Medicine Centre (PHARMBIOTRAC) will be the region's center of excellence (Arbo and Benneworth, 2007; Salmi *et al.*, 2016) in science driven TM and Pharm-biotechnology. The centre will specialize in systematic identification, documentation, mapping, conservation, commercialization, harvesting, extraction, isolation, characterization, structural elucidation and modification of active molecules from plants and other life forms for production of high value science driven TM and biopharmaceutical products for uptake by pharmaceutical and herbal medicines industries in the region.

The main objective of PHARMBIOTRAC is to build a critical mass of specialized and skilled human resource that can advance traditional medicine and Pharm-Biotechnology for socio-economic development of Africa. The specific objectives are to;

- i. Strengthen capacity in the region to train highly skilled and specialized professionals in traditional medicine and Bio-pharmaceuticals,
- ii. Strengthen capacity in the region to engage in cutting edge research in TM and systems biology for health products development,
- iii. Create capacity in collaboration with private sector industry for development, production and commercialization of TM, biopharmaceuticals and nutraceuticals from research outputs,
- iv. Advance the practices of TM/TMK in the region and promote domestication and sustainable utilization of medicinal species.

Operationalisation of PHARMBIOTRAC

Mbarara University of Science and Technology (MUST) is mandated to teach both undergraduate and graduate programmes (MSc and PhD), as well as short courses. The University also promotes transfer of scientific knowledge and innovations to the community for sustainable society transformation. PHARMBIOTRAC will attract multidisciplinary students from the region including botanists, biochemists, chemists, pharmacognocists, engineers, pharmacologists, pharmacists, microbiologists, biotechnologists, entrepreneurs, and train them through transdisciplinary approaches to build teams for joint projects and enterprises. PHARMBIOTRAC will use scientific methods to improve TM products and to identify active molecules that can be developed into biopharmaceuticals. To achieve its goal, PHARMBIOTRAC will augment its existing teaching faculty by attracting and recruiting specialist hands-on scientists and practitioners from the region and mentor them in collaboration with professors from partner universities in USA, India and South Africa. The centre, through the transdisciplinary approach of graduate training and specialization will support the development of science-driven TM products and biopharmaceuticals, leading to their commercial production in the region by private sector industries. Through linking of research and education to industry, the research outputs and the graduates will be absorbed by private sector industry to mass produce high value science driven TM products (e.g. Weathers *et*

al., 2014; Ogwang *et al.*, 2015) and biopharmaceuticals which are highly needed for disease control and prevention worldwide. The application of Pharm-biotechnology particularly systems biology will spur drug discovery, which in turn would lead to production of biopharmaceuticals for national, regional and international markets. In addition to biopharmaceutical industry, the graduates of PHARMBIOTRAC will serve as faculties in partner universities, and other organizations in the region to train more specialists in TM and biopharmaceuticals.

Over the project period of five years, PHARMBIOTRAC is envisioned to have some significant outputs, not least, producing specialized and highly skilled graduates who can contribute positively in validating the efficacy of TM with clinical evidence. This is expected to promote use of TM by biomedical health practitioners, leading to potential investment in TM related drug discovery and products development by the private pharmaceutical industry, hence improving quality of life and productivity of the people in the region. Table 1 provides summary of the expected results of PHARMBIOTRAC and anticipated impacts.

PHARMBIOTRAC Action Plan to Achieving Learning Excellence

In order to achieve learning excellence PHARMBIOTRAC will strive to attract and retain a high concentration of talent academics and graduate students (Salmi *et al.*, 2016). This will help achieve its objective of strengthening capacity to train high quality, specialized and skilled African graduate students at MSc/PhD levels in Traditional Medicine (TM) and Pharm-Biotechnology specialities. In the process PHARMBIOTRAC will be benchmarked with: a) three universities/institutions internationally for best practices, b) curriculum review will be undertaken and new programmes developed, and c) efforts will be made to attract specialists to support the centre activities. Detailed descriptions of how this action plan will be archived are entailed in the following steps:

a) Benchmarking best practices. Three universities (FLIRT in India, University of KwaZulu Natal in South Africa, and Worcester Polytechnic Institute in USA) and one advanced knowledge research institution (KEMRI, Kenya) will be benchmarked by PHARMBIOTRAC for the design of new MSc and PhD programmes as well as other attributes for alignment to fundamental characteristics of well-performing tertiary education institutions. This is to stimulate training of highly sought graduates, conducting leading-edge research, and ensuring dynamic technology transfer (Arbo and Benneworth, 2007; Salmi *et al.*, 2016).

b) Attracting specialized faculty. PHARMBIOTRAC will attract some carefully selected full time senior faculty with PhD in biotechnology and other specialities in order to strengthen the pharmbiotechnology teaching and research in transcriptomics and genomics so as to produced sufficiently hands-on skilled graduate. It is expected that the graduates will be experts in reverse metabolomics, genomics and proteomics (molecular characterization, structural elucidation and modification of drug molecules or drug receptors); and specialists in production and use of high value biopharmaceuticals and Traditional Medicine products for uptake by pharmaceutical and herbal medicines industries in the region and beyond. In

Table 1. Some of the envisioned outputs of PHARMBIOTRAC within the next five years

Expected result	Anticipated outcome and impacts
30 PhD graduated (At least a third of them female; and 30% regional students)	Capacity built through training of their staff at MSc and PhD in TM and biopharmaceuticals research, development and production
60 MSc graduated (At least a third of them be female; and 30% regional students)	Capacity built through training of their staff at MSc and PhD in TM and biopharmaceuticals research, development and production
At least 2 new graduate programs developed (nationally & regionally/internationally accredited)	Human capital developed in critical field of TM drug discovery, development & production
At least 150 peer reviewed publication in international reputed journals	Research findings of PHARMBIOTRAC reach wider scientific community, policy makers, and publications of staff resulting into promotion to higher academic rank, e.g. professorship
At least 8 drug molecule patents registered	Patents and licensed products, and royalties
At least 2 research projects jointly launched with private sector and or partner universities.	Promoting Private -Public-Partnership (PPP)
At least 2 TM products licensed for commercial production by national or regional private sector industry	Promoting Private-Public-Partnership (PPP), hence ensuring sustainability of funding
At least 2 product monographs produced	Product monographs may attract wider audience ensure products reach potential customers
At least 5000 Traditional Medical Practitioners (TMPs) fully trained through short courses	Provision of better TM services and improvement in the populations' quality of life, life expectancy and economic productivity.
At least 100 Herbal medicine producers trained in tailor-made short courses on quality, safety and efficacy of their products in line of Good Manufacturing Practices (GMP)	Improved quality of Herbal medicine products on local market
At least 5 conferences organized by PHARMBIOTRAC	PHARMBIOTRAC well publicized among all key stakeholders/partners, and potential graduate students from Eastern and Southern Africa made aware of opportunities at PHARMBIOTRAC

Table 1. Contd.

Expected result	Anticipated outcome and impacts
At least 275 conference presentations by students and faculty (at national, regional and international level)	Research findings of PHARMBIOTRAC reach wider scientific community, policy makers, and resulting in scientific networking and new collaborations
Regional students, faculty and governments highly attracted to PHARMBIOTRAC & its services	PHARMBIOTRAC, a true Africa Higher Education Centre of Excellence

addition, PHARMBIOTRAC will also attract short term specialist faculty with diverse expertise from the regional and international universities (industrial experts inclusive) through expert-friendly teaching models allowing them to teach in compact block modules within a period of 2-4 weeks and also mentor staff. Retired senior experts will be engaged for 1-2 years renewable contracts for knowledge and skills transfer to students and providing mentorship to staff. These staff will be drawn through international and regional professional networks, online sourcing and specialized senior Expert Personnel Sending organizations (Senior Expert Services Germany, German Academic Exchange Service, Fulbright fellowship programme, Voluntary Service Overseas and others). The majority of teaching faculty, however, will be young talented and promising scientists drawn from Eastern and Southern Africa.

c) Developing new Programmes. It is planned to develop three new programs MSc in Reverse Metabolomics and Drug Discovery, MSc in Traditional Medicine and Drug Production Systems; and MSc in Traditional Medicine and Biotherapeutics. PHARMBIOTRAC staff drawn from core departments at MUST and supported by national, regional and international academic partners and private sector partner such as Cipla/QCL will be engaged in developing the curricula that will involve hands-on training and will be tailor-made to reflect market demand (Salmi *et al.*, 2016). The curricula developed will create specialists in metabolomics, drug discovery, biomanufacturing of medicines and science based TM practice to fill the current huge gap.

d) Accreditation of the new courses. New programmes will be submitted for accreditation at national level to the National Council of Higher Education Uganda (NICHE) following guidelines outlined in the Statutory Instruments No.34 (2008) for the Universities and Other Tertiary Institutions (Quality Assurance) Regulations and which is available at the link below: <http://www.unche.or.ug/wp-content/uploads/2014/03/Statutory-Instruments-No.342008-the-Universities-and-Other-Tertiary-Institutions-Quality-Assurance-Regulations-.pdf> . In addition, for international accreditation, accreditation agencies will be sought for the new programmes. We, however, do acknowledge that international accreditation might take longer to archive, nevertheless, the following organizations are earmarked for guidance in the accreditation process; (i) Society for Medicinal Plant and Natural Product Research (GA), Germany www.ga-online.org; (i) Pharmaceutical Biology and Biotechnology, Institute for

Pharmaceutical Sciences, University of Freiburg, Germany <http://www.plant-sciences.uni-freiburg.de/psf-plant-research-molecular-pharmacognosy.html>; (iii) Society of Pharmacognosy, India <http://indiansp.com/>

e) Implementation of the courses. The curricula once developed and accredited for the training and skilling talented MSc and PhD graduate students will be implemented initially at the PHARMBIOTRAC-MUST. Facilities and laboratories will be upgraded for learning and research. The pharm-biotechnology laboratory and small scale herbal medicine production units will be set up to augment existing laboratories. A TM learning and research clinic will be established at the MUST teaching hospital for reverse pharmacology and clinical trials. The program will include integrated and specialized taught course units, co-research/ projects, and peer research experiences with partnering institutions. The candidates will be selected on merit through a rigorous and transparent process using theoretical and practical screening tests. The PHARMBIOTRAC masters and PhD graduate courses will be reviewed through Peer-peer staff evaluation, and student evaluating faculties and lecture session, external examiners and annual course review meeting involving all partners, government line ministries, and other relevant developments organizations. Modern ICT technologies such as video conferencing, online course platforms, mobile applications and student lecturer interaction tools will be used to facilitate teaching and skills development. This will provide a basis for team-based learning and experiential learning at the centre and from partnering institutions. The use of ICT will facilitate utilization of renowned international experts and professors from partnering institutions such as WPI in the USA, KZN in South Africa when they cannot physically be present.

f) Market-oriented short courses at PHARMBIOTRAC. Short courses will be offered targeting a wide range of in-service group including Traditional Medicine practitioners, Biomedical Health Practitioners (including doctors, nurses, and physiotherapist) and other professionals coming from communities, research institutions, academia, industry, governmental and non-governmental organizations in Eastern and Southern Africa and beyond. The courses will cover a wide range of specialized training including; entrepreneurship, start and grow your business, innovation management and value chain. In addition, courses targeting TM practitioners and interested public in the area of TM-clinic, and pharmacy management, basics in herbal medicine making, formulation, preservation, packaging labelling, ethics and professionalism, in-situ and ex-situ conservation, domestication and cultivation of indigenous African medicinal plants, sustainable harvesting and post-harvest handling will be implemented to advance TM.

g) Impact of graduate programmes. The MSc/PhD courses (2-3/3-5 years) will prepare graduates to become future world leaders in drug discovery, development, production, market surveillance and modern TM practitioners in the region. To achieve this, MUST staff who will be students of the centre particularly those on PhD track will receive scholarship for attachment to world class laboratories of professors in the USA and India to receive training and experience in modern technology for drug studies and bio-manufacturing.

Table 2. PHARMBIOTRAC partners including national, regional and international

No.	Partner abbreviation	Partner name	Partner role
1	BSU	Bishop Stuart University	PHARMBIOTRAC will support staff development at BSU by training its staff at MSc and PhD. It will grant funds for establishment of medicinal plant herbarium and medicinal gardens. In addition, BSU will provide ethnobotanist to work with ethnobotany unit at PHARMBIOTRAC
2	GU	Gulu University	PHARMBIOTRAC will support staff development at GU by training its staff at MSc and PhD. It will grant funds for establishment of TM research and training clinic at GU University teaching hospital, medicinal plant herbarium and medicinal gardens
3	Mak-CoNAS	Makerere University College of Natural Science	Will be utilized in developing curriculum for pharm-biotechnology and establishing training at PHARMBIOTRAC, as well are training of graduate students
4	UTAMU	Uganda Technology and Management University	Will help in ICT establishment systems for databases of students, staff, visiting experts, TMK documentations, financial and quality assurance systems, computer aided drug design systems and various e-learning systems for students and staff
5	UKZN – South Africa	University of KwaZulu-Natal	Benchmarking, curriculum for TM and TMK information systems, IK documentation at PHARMBIOTRAC.
6	UOFG – Sudan	University of Gezira	Strong and well equipped pharmacy lab utilized for training of PHARMBIOTRAC students structural elucidation of molecules isolated from TM and other life forms
7	UCM – Mozambique	Catholic University of Mozambique	Send its staff to PHARMBIOTRAC for training & capacity building the field of pharmaceuticals and TM for its College of Health Sciences
8	WPI – USA	Worcester Polytechnic Institute Massachusetts	Will host and train PHARMBIOTRAC staff and best MSc and PhD students in the field of biotechnology (i.e. staff & student attachments to its world class laboratories)

Table 2. Contd.

No.	Partner abbreviation	Partner name	Partner role
9	IHST – India	Institute of Transdisciplinary Health Sciences and Technology at Transdisciplinary University	Benchmarking, curriculum for TM & TMK, experience of India in research of TM sectors Ayurveda and Unani. Will host and train PHARMBIOTRAC Staff and students (i.e. staff & student attachments to its world class laboratories)
10	KEMRI-CTMDR – Kenya	Kenya Medical Research Institute, Center for Traditional Medicine and Drug Research	Benchmarking, curriculum for TM & TMK, KEMRI has specialized laboratories for study of disease-causing agents which will be utilized by PHARMBIOTRAC students for specialized research in drug discovery studies (i.e. staff & student attachments to its world class laboratories)
11	NCRI	Natural Chemotherapeutics Research Institute	Will send some of its staff for capacity building at PHARMBIOTRAC at MSc and PhD level. NCRI will also be an inter-link between the centre and the ministry of health especially on policy issues and adoption of medical technologies developed by the centre
12	Cipla-QCL	CIPLA Quality Chemical Industries Limited Uganda	Will collaborate with PHARMBIOTRAC to develop biopharmaceuticals from natural molecules discovered from TM and other life forms by PHARMBIOTRAC. Also provide space for industrial training for MSc & PhD students
13	EHC	Excel Hort Consult Ltd.	Will work with PHARMBIOTRAC in the establishment of high-value production lines for TM products. Also serve as internship/industrial attachments units for students to learn TM products value chain
14	KHP	Kazire Health Products Ltd.	Will collaborate with PHARMBIOTRAC to develop nutraceuticals from natural molecules discovered from TM and other life forms by PHARMBIOTRAC. Also provide space for industrial training for MSc & PhD students

Table 2. Contd.

No.	Partner abbreviation	Partner name	Partner role
15	BUMETHA	Bushenyi Medical & Traditional Healers Association	In addition to providing TMK holders, will also host students in their engagement with TMK holders and communities which is a key component of this project.
16	UNCST	Uganda National Council for Science and Technology	Will champion all aspects of research ethical clearance and permit as well as national documentation, and will also link PHARMBIOTRAC to policy.
17	RUFORUM	Regional Universities Forum for Capacity Building in Agriculture	Will champion information dissemination for attraction of students and expert faculty from the region through its wide network and experience in academic information dissemination.
18	AICAD	African Institute for Capacity Development	PHARMBIOTRAC will develop collaborative community capacity building activities with AICAD in the area of TM and TMP to extend quality services to rural communities.

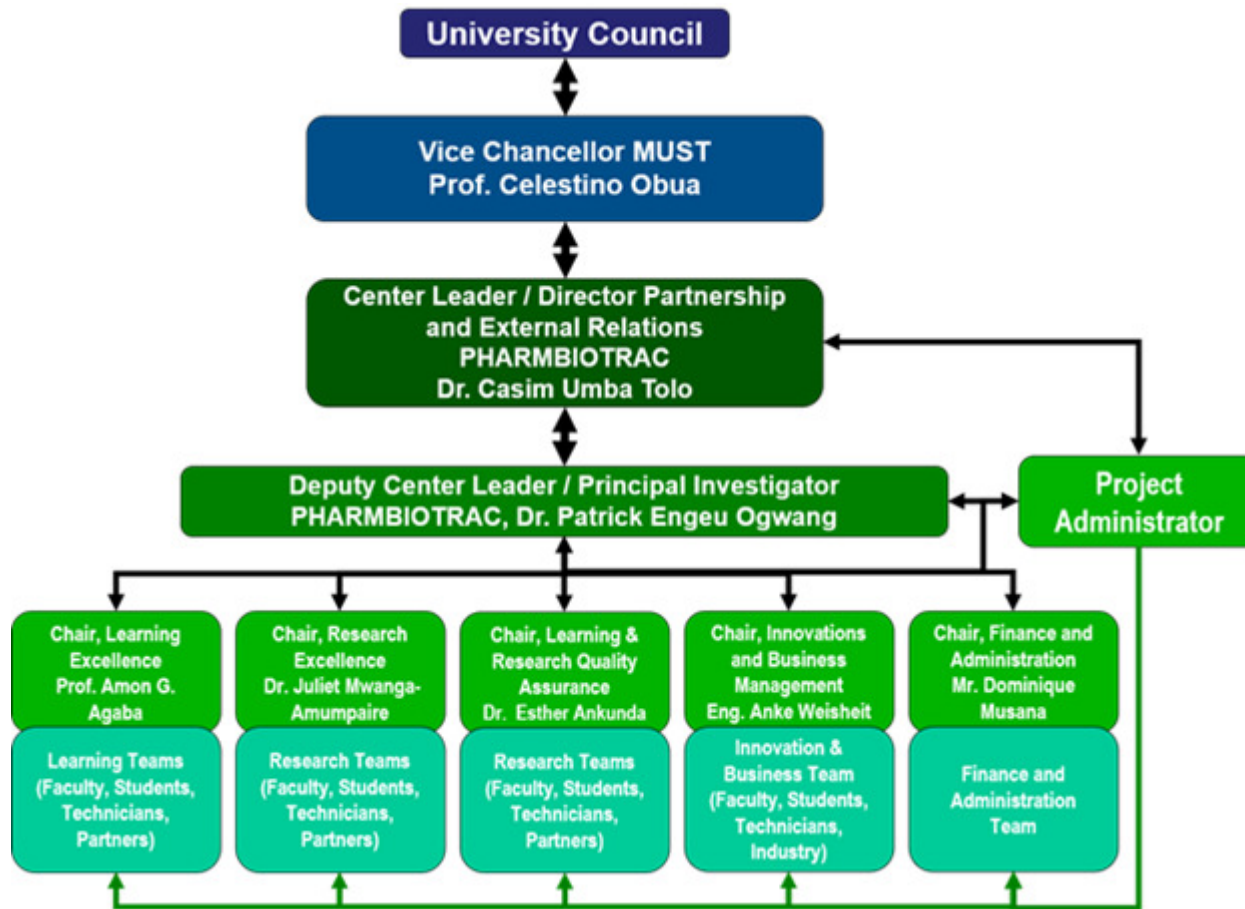


Figure 1. Organizational Chart of PHARMBIOTRAC

h) Impact of short professional courses. The graduates of these short courses will have better knowledge and skills in the practice of traditional medicine, product development, research, regulations and business management. This is expected to transform TM in the region leading to provision of better TM services and improvement in the populations' quality of life, life expectancy and economic productivity.

Partnerships of PHARMBIOTRAC

A total of 18 partners with vast experience and expertise in various fields of Pharm-Biotechnology and Traditional medicine are involved in PHARMBIOTRAC activities (Table 2). The collaboration is anticipated in various ways including;

- i) visiting lectureship, Student placements, external examiner secondment, external supervision, etc.
- ii) joint research and publication, whereby more research grants are sourced through proposal writing and networking. In this case, it is of great advantage to have a diverse pool of partners from where consortia can be constituted for joint future engagement, outreach and sustainability.

Acknowledgements

We acknowledge the financial support extended to us by Mbarara University of Science and Technology (MUST) that made it possible to prepare a successful proposal to the World Bank to establish PHARMBIOTRAC. We are equally grateful to RUFORUM who facilitated the proposal development and funded Dr. Casim Umba Tolo to showcase the PHARMBIOTRAC project at the Fifth African Higher Education Week and RUFORUM Biennial Conference held at Century City Conference Centre, Cape Town, 17-21 October 2016. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

References

- Arbo, P. and Benneworth, P. 2007. Understanding the regional contribution of Higher Education Institutions: A literature review. A research report prepared for the OECD-IMHE project "Supporting the Contribution of Higher Education Institutions to Regional Development". Education Working Paper No. 9.
- Goddard, J.B. and Chatterton, P. 2003. The response of universities to regional needs. In: Boekema, F., Kuypers, E., Rutten, R. (eds.), *Economic Geography of Higher Education: Knowledge, Infrastructure and Learning Regions*. London: Routledge.
- Jamil Salmi, Ying Cheng and Nian Cai Liu. 2016. Benchmarking Institutions of Applied Sciences, Engineering and Technology (ASET) in Sub-Saharan Africa: Revised Methodology. A concept presented at the First PASET Regional Benchmarking Capacity Building Workshop 14-16 June, 2016, Abuja, Nigeria.

- Ogwang, P. E., Tumusiime, R., Agwaya, M., Mugisha, G., Nambatya, G.K., Galiwango, B. and Waako, P. 2008. Repeated-dose effects of *Zanthoxylum chalybeum* root bark extract: A traditional medicinal plant used for various diseases in Uganda. *African Journal of Pharmacy and Pharmacology* 2 (6): 101-105.
- Ogwang, P. E., Nambatya, G. K., Omujal, F., Agwaya, M., Nusula, N., Kyakulaga, H., Ogwal-Okeng, J., Ejobi, F., Kabasa, D., Olila, D. and Obua, C. 2015. Variations in antimalarial and mosquito repellent components of *Artemisia annua* L. cultivated and used by communities in Ugandan. *Afr J Health Sci.* 28 (1): 95-102.
- Weathers, P.J., Towler, M., Hassanali, A., Lutgen, P. and Ogwang, P.E. 2014. Dried-leaf *Artemisia annua*: A practical malaria therapeutic for developing countries. *World Journal Pharmacol* 3 (4): 39-55.