Requirements Engineering for Digitizing Traditional Medical Knowledge: The Case of Building Phytomedicine Mobile-Web Application in Tanzania

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ABSTRACT

The digitization of traditional medical knowledge in Tanzania will greatly enhance its preservation and dissemination. This is especially important given the challenges facing the current methods of preserving and managing such knowledge. This study presents the requirements engineering approaches and requirements for a web-mobile application that would successfully digitize indigenous knowledge of phytomedicine and relevant practitioners licensing and registration processes. To establish the requirements of such a digital system application, the study sought the opinion of 224 stakeholders whose suggestions were used to analyze and model the requirements for designing such a web-mobile tool. The study was carried out in Arusha, Kagera and Dar es Salaam regions of Tanzania which involved ethnobotanical researchers, herb practitioners, curators from herbaria and registrar officers from Traditional and Alternatives Health Practice Council. Structured interview, survey, observation and document review were employed to find out the basic functional and non-functional requirements for possible designing and implementation a web-mobile application that would digitize indigenous knowledge of medicinal plants. The requirements were modelled using the use case and context diagrams. Finally, the study came up with a list of items for both functional and non-functional requirements that can be used as guidelines to develop a web-mobile application that will capture and document traditional medical knowledge of medicinal plants in Tanzania and, enabling relevant authorities to regulate and manage stakeholders.

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1. Introduction

World Health Organization (WHO) describes traditional medicine as the knowledge, skills and practices based on the theories, beliefs and experiences of different cultures, used in maintaining and preventing the health, diagnosing, improving or treating physical and mental illness. When such practices make use of plant materials it is known as phytomedicine and such knowledge is referred to as traditional medical knowledge (TMK) (Anyaoku, Nwafor-Orizu, & Eneh, 2015; Liwa, et al., 2017; Mahomoodally, 2013). Traditional medicine is used widely in most developing countries as a major source for health care. Majority (80%) of the population from Africa, Asia and Latin American countries practice traditional medicine either independently or simultaneously with other conventional approaches (Haouari et al., 2018; Mahomoodally, 2013).Traditionally, TMK is preserved and passed on orally to subsequent generations. However, TMK has been lost gradually due to inability of the current methods and approaches used for preserving and maintaining it (Kayombo, Mahunnah, & Uiso, 2013).

The government of Tanzania adopted and recognized traditional medicine as an alternative treatment through its Traditional and Alternative Medicines Act of 2002 (The United Republic of Tanzania, 2002) in order to ensure safety among the stakeholders. The adoption involved the creation of Traditional and Alternative Health Practices Council (TAHPC) that is tasked with the responsibility of controlling and regulating traditional medicine practices and traditional medical practitioners (TMPs). Regulation process by the council involves issuance of premise licenses for such practices. However, these activities and processes are done manually hence making the process slow and hard to keep track and retrieve the stored information.

There has been a need for documenting TMK with the use of information and communication technologies (ICTs) so as to prevent and minimize its extinction and disseminate it to stakeholders who recognize and use traditional medicine (Koumpouros & Birbas, 2013). However, any kind of software that could be developed to satisfy such existing need, will have to meet the system requirements that include unambiguity, compatibility, correctness and completeness. Moreover, the software should achieve the intended goals since the accomplishment and success of any developed software is evaluated in terms of client's satisfaction (Pandey & Pandey, 2012).

Software development life cycle (SDLC) is an approach that employ phases to the systems development include planning, analyzing, designing, implementation and maintaining it (Kendall & Kendall, 2013). In this case, requirements engineering (RE), which is analysis phase, is believed to be the most important phase in the entire SDLC. This is because, any error produced can be detected at this stage as far as fulfilment of the business or user requirements are concerned (Matyokurehwa, Mavetera, & Jokonya, 2017). Therefore, RE refers to the systematic approach of generating and managing both functional and constraints requirements from clients input regarding their needs (Levy, Hadar, & Aviv, 2019). It comprises all processes, approaches and technics that are employed to acquire requirements for developing specific software. It encompasses four high-level activities: (1) the assessment of the usefulness of the system (feasibility study), (2) discovering the requirements in the real world (requirements gathering), (3) defining requirements in a standard form (specification), and (4) confirmation of whether the requirements are meeting the clients' needs (validation)

(Sommerville, 2011).

This study explores and presents both basic functional and non-functional requirements that can be adopted by software engineers to develop a web-mobile application platform for digitizing TMK and integration of a module for TMPs registration and licensing in Tanzania. The study also presents the approaches used during determination of the relevant requirements. To achieve the objectives of this study, the following research questions were formulated:

- RQ1. What are the preliminary functional and non-functional requirements for developing a digital application platform for TMK in Tanzania?
- RQ2. What are the suitable approaches that could enhance requirements elicitation, analysis and modelling for digitizing TMK?
- RQ3. How could the elicited requirements be improved to meet stakeholders' needs?

2. Literature Review

2.1 Medicinal Plants in Developing Countries

Traditional medicine has been used by many indigenous people since ancient times and still finds application in health sector and modern medical practices (Yuan et al., 2016). The knowledge about traditional medicine is stored in the mind of individuals but such knowledge disappears under the passage of generations. Death, lack of learning interest by subsequent younger generation, memory loss by current knowledge holders due to ageing, are the contributing factors towards the loss of TMK (Kayombo, Mahunnah, & Uiso, 2013).

Medicinal plants are the most common traditional medicine in developing countries. Indeed such medicine has become popular in the prevention and treatment of both human and animal diseases (Ozioma & Chinwe, 2019). Nearly 70-85% of healthcare of the people from Tanzania and other countries in Africa are dependent on traditional medicine (Liwa et al., 2017; Antwi-Baffour et al., 2014). Research reports show that about 25-30% of modern drugs are the by-products of medicinal plants which stand to be the main future source of modern medicines (Kayombo, Mahunnah, & Uiso, 2013; Shakya, 2016; World Health Organization Regional Office for Africa, 2012). Moreover, traditional medicine can be exploited for possible commercialization by knowledge owners (Abbott, 2014). It is due to this great role played by medicinal plants that the United Nations Educational, Scientific and Cultural Organization encourages safeguarding of TMK by documentation for development, use and maintenance by present and future generation (UNESCO, 2003).

Considering the potential role played by traditional medicine in the health system of the people, some developing countries have enacted laws and established councils while others have passed bills to regulate the use of such medicine and relevant practitioners (Government of Zambia, 2016; Harrington & Harrington, 2018; Ministrary of Health, Ghana, n.d.; The United Republic of Tanzania, 2002). Such regulatory laws seem to be similar in these countries, where at least each country has well defined practice of complementary medicine and relevant councils that work to regulate

the use of the medicine and traditional practitioners. Indeed, it is encouraging to see efforts of regulating the use of traditional medicine by countries to ensure people's safety. However, the challenge still remains on the preservation of such useful knowledge which is at risk of gradual extinction due to the current methods that are used in preserving such knowledge.

2.2 The Role of Requirements Engineering in Software Development

Requirements engineering is a systematic approach that involve elicitation, analysis and documentation of requirements for developing any software (Pandey & Pandey, 2012). Goals of developing any software can be achieved if the resultant software developed satisfies clients' needs. Requirements engineering involves four activities at a high level which include feasibility study, requirements gathering, specification and validation (Wu et al., 2016).

In software development, requirements engineering is vital as it assists the systems analyst to discover the requirements in the early stages. In case the requirements are not identified in time, the system will result into defects that will prove costly in the process of fixing them (Chakraborty et al., 2012). Rightly defined requirements help to prevent and minimize errors that can occur due to requirement failure. Therefore, requirements engineering reduces risks in the entire process of software development and improves the quality of developed software (More, Sapre, & Chawan, 2011). Moreover, whenever a software system is developed, both of its functional and non-functional requirements must be well assessed to ensure that the system works to meet users' expectations. Functional Requirements (FR) refers to the services offered by a system while nonfunctional requirements (NFR) are the constraints under which a certain system should operate and both FR and NFR are essential in the implementation of any software (Becker et al., 2019). Example of functional requirements include report viewing and printing while privacy, reliability, capacity and usability are examples of non-functional requirements.

2.3 Related Works

Digitization of Traditional knowledge has been done in India where a digital library referred to as Traditional Knowledge Digital Library (TKDL) was developed to document traditional knowledge of medicine by the local communities in India and to protect such knowledge from bio-piracy (Nadkarni & Rajam, 2016). Although TKDL is a web-based application, studies indicate that TKDL captured knowledge that were already documented on books. Additionally, TKDL has no feature for managing practitioners thus the world intellectual property (WIPO) only proposes it to be used as a model due to variation of requirements for each specific country. A similar mobile application was developed in Indonesia that was essentially meant to meet the relevant requirements for the people in the country (Hidayat et al., 2016).

In China, a study was conducted to integrate different databases that would store information about traditional Chinese medicine by developing a tool known as Traditional Chinese Medicine Integrated Database (Xue et al., 2012). The idea of integrating these databases was influenced by its inconsistency in handling those data. However, the requirements captured were insufficient in

handling traditional or indigenous knowledge since they were based on herb ingredients and the corresponding diseases, they treat in which traditional knowledge about such plant was not clearly defined. Furthermore, a study aimed as analyzing user requirements for developing a web portal for herbaria data management was conducted in Belgium but it was based on only taxonomic information rather than indigenous knowledge (Vissers et al., 2017). Most of the studies that have been done on the requirements engineering for TMK digital systems are localized none of them described the requirements for managing practitioner's registration processes by the relevant authorities.

3. Methodology

3.1 Study Area and Sample Size

To establish the initial requirements for a digital tool that should be built to satisfy the needs of traditional medicine stakeholders, the study involved three phases which were feasibility study, elicitation and analysis, requirements specification and documentation for collecting primary data while secondary data were obtained from the National Herbarium of Tanzania (NHT). The study was conducted in Arusha, Kagera and Dar es Salaam regions of Tanzania involving 156 herb practitioners, 60 ethnobotanical researchers making up a total of 216 respondents who participated in a survey. Structured face to face interview involved 6 curators and 2 practitioner registrars from Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDEC).

Researchers and curators involved in this study were from the Institute of Traditional Medicine (ITM), NHT and the herbarium of the University of Dar es salaam. Practitioners were from the Kagera and Arusha regions that are well known in the practice of traditional medicine by Tanzanian local communities (Moshi et al., 2010; Stanifer et al., 2015). The functional requirements established, were represented with use case and context diagrams to illustrate the interaction between the proposed system and its users, and the data flow respectively.

3.2 Requirements Engineering Process

3.2.1 Stage1: Feasibility Study

To examine the usefulness of the proposed web-mobile application for managing TMK and stakeholders, a feasibility study was carried out using questionnaire. The intended collected information during the survey was meant to establish the perception of ethnobotanical researchers and practitioners towards the adoption and practice of ICTs in documenting TMK and auto-registration of practitioners by the government authorities.

3.2.2 Stage2: Requirements Elicitation and Analysis for a TMK Web-mobile Application

User requirements for implementing a web-mobile application tool that suits traditional medicine

stakeholders needs were discovered form ethnobotanical researchers, practitioners, curators and TAHPC registrar. Interview guide and questionnaires were administered to gather the requirements while observation and document review were employed in collecting the needed information in the field of traditional medicine. Researchers and practitioners participated in a survey while an interview was administered to curators and practitioners registrar. The gathered requirements were sorted and classified into clusters of functional and non-functional requirements.

3.2.3 Stage3: Requirements specification

The user requirements were categorized into sub-system menus such as user management, plant management, indigenous knowledge, knowledge source, literature and practitioner's management menu. A software requirements specification (SRS) document for both functional and non-functional requirements was produced.

3.3 Study limitation and ethical consideration

This study was authorized and approved by NM-AIST and MoHCDEC to be carried out. During data collection, participants were informed about the objective of the survey and their consent to be involved in the study was sought. Researchers and practitioners that participated in data collection were ethnobotanical researchers and herbalists.

4. Results

4.1 Feasibility report

Table 1 shows the findings on feasibility study, 74.5% of two hundred and sixteen (216) respondents, indicated that there is a need for a digital tool to document and maintain maintaining TMK. Additionally, more than three-third (84.5%) responded that ICT tools are crucial in the practice of traditional medicine. Majority (82.41%) and 73.34% suggested that using digital systems can minimize the loss of TMK and TMPs registration can be improved.

Table 1. User's opinions toward the use of digital tool in TMK management

User's opinions	Respondents	Percentage (%)
A digital tool for preserving TMK is needed	161	74.50
In the practice of traditional medicine ICT tools are essential	174	84.50
I believe that a digital tool can reduce TMK extinction	178	82.41
The registration of TMPs can be enhanced with the use of digital systems	114	73.34

4.2 User Requirements

Stakeholders who participated in the study suggested a number of features they would wish to see in an application that would manage TMK and stakeholders. They indicated that the application should execute various functions that include capturing and documenting information on TMK and enables license application process by practitioners. Other requirements were obtained through observation and document review. The proposed requirements can be further improved during the implementation of such an application by employing evolutionary prototyping model which involve user feedback. Table 2 and Table 3 indicate the proposed user requirements as suggested by the stakeholders.

Table 2. User requirements acquired through survey

SN	User Requirements Feature	Respondents	Percentages (%)
1.	Upload information about medicinal plants	178	82.41
2.	Upload local believe about medicinal plants	56	25.93
3.	The tool should be able to indicate the list of herbs and the relevant traditional knowledge	197	91.20
4.	Include the approval of medicinal plants before publishing it	45	20.83
5.	Include scientific information of medicinal plant species	58	26.85
6.	Searching tool for the information about medicinal plants	159	73.61
7.	I should be able to print the data after searching	30	13.89
8.	Include the formulation process in the documentation of TMK	77	35.65
9.	Information about new innovations from herb remedies	7	3.24
10.	An option to control publication of stored information about medicinal plants	58	26.85
11.	Profile management of personal information	100	46.30
12.	Upload image on personal profile	130	60.19
13.	Indicate the source location of medicinal plants	68	31.48
14.	Capture methods of treatment and formulation process of traditional medicine	60	27.78
15.	Include the distribution of medicinal plant species	5	2.31
16.	An option to disseminate the knowledge to the public	38	17.59
17.	There should be a mechanism to control knowledge dissemination that is not in the public domain	11	5.09
18.	An option to respond to queries from clients	2	0.93
19.	Allow feedback mechanism	65	30.09
20.	Incorporate a module for registration of traditional practitioners through the system	154	71.30
21.	Herbalists/ practitioners account for personalized space	144	66.67
22.	List of registered practitioners for herb remedies	50	23.15
23.	Provide access to practitioners to share their knowledge	110	50.93
24.	Provide practitioners license electronically	10	4.63
25.	The tool should be easy to use with simple interface	66	30.56
26.	The tool should operate in Swahili and English language	170	78.70
27.	I wish the tool to be accessible in computer, smartphone or tablet	93	43.06

Table 3. User requirements acquired from curators and TAHPC registrar officers through interview

Respondents	User requirements
Curators	- Having a web application can simplify the retrieval and dissemination of TMK - The system should be able the preliminary information of medicinal plants to capture i.e. plant local name, preparation process, dosage, plant location, local belief (village/street, ward, district and region), information source or knowledge owner, and habitat - The system should be able to assist curators in the herbarium to capture scientific information including plant species, genus and family - The system should provide an option to control dissemination of traditional knowledge of medicinal to the public - I wish to be able to search and generate reports of available information of TMK
TAHPC registrar officers	- I wish practitioners to apply for registration using an online application - The system will be helpful if it will generate practitioners license automatically - The system should allow registrar to view practitioners applications and approve online - Registrar should receive notification on new application - registrar should view available applications and the status - registrar should generate and print repots for registered and non-registered applicants

4.3 Requirements Modelling

4.3.1 Use Case modelling

Although use cases diagram are not robust in the discovery of domain requirements and constraints to which the system should operate, it's more effective in process eliciting and modelling functional requirements for developing any software (Sommerville, 2011).

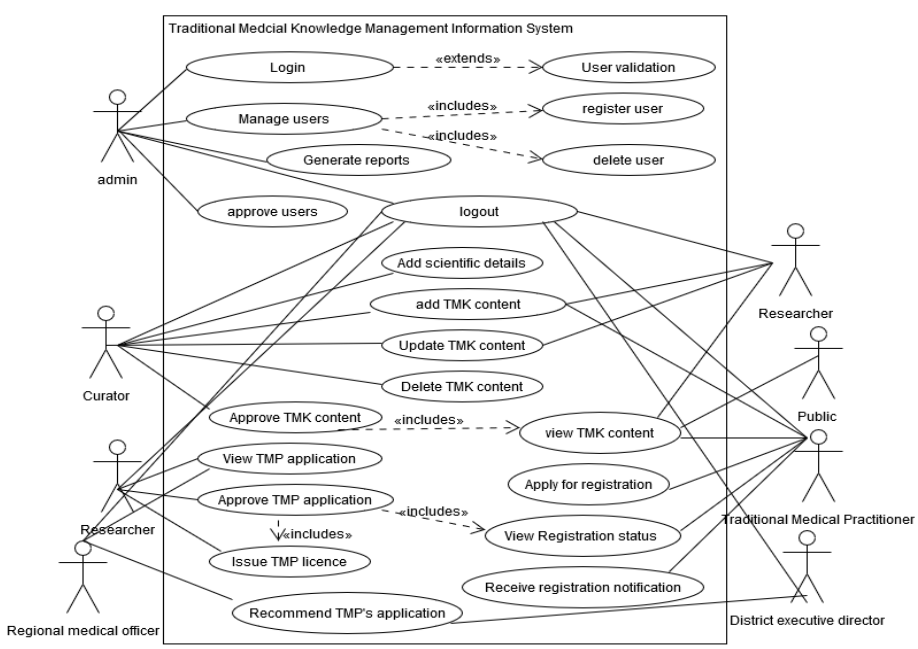

Fig. 1. A use case model for TMK web-mobile application

Use case diagram are used to represent user's interaction with the system based on the requirements specifications of the tool. Fig. 1 is a use case diagram showing how users interact with the tool. The use case had a number of actors who directly interacted with the system i.e. Admin, researcher, curator, traditional Medical practitioner, TAHPC registrar, district executive director, regional medical officer and the public. The description of each use case is given in Table 4.

4.3.2 Use Case Description of Functional Requirements for TMK Web-mobile Application

Table 4. The Description of the Use Case for web-mobile application based on the functional requirements

Use Case	Description	Actors	Pre-condition	Post-condition
Login and logout	Users will sign to the system	Researcher/Curator Administrator/Surveyor/ Traditional medical practitioner/TAHPC registrar/Regional medical officer/District executive director	Users should be registered into the system and should provide valid credentials	User system access will be granted
Add, view, update, approve users	Users will be added to the system	Administrator/Curator	Administrator and curators should be signed in to the system	Administrator and curators will add, view, update and approve added users
Add TMK data	Traditional knowledge of Medicinal plants will be added/uploaded	Researcher/curator/ Surveyor/Traditional medical practitioner	User should be signed in to the system	Traditional knowledge of medicinal plants data will be added to the system
Update TMK data	Information about TMK can be updated	Researchers/curator/ Surveyor/Traditional medical practitioner	Users should be signed in to the system Users should granted edit access	TMK information will be updated
Publish TMK data	TMK information that is in the public domain will be published	Curator	User needs to be signed in to the system Users should be granted edit access TMK data should under public domain	Available TMK data will be published
Generate reports	The system can display requested reports	Researcher/Curator Administrator/Surveyor/ Traditional medical practitioner/TAHPC Registrar	User needs to be signed in to the system User should granted a privilege	Various reports on users and TMK data will be viewed
Apply for Registration	Traditional medical practitioner will apply for the license depending on the services	Traditional medical practitioner	User should create the account User should be signed into the system	Traditional medical practitioner will be able to apply for license registration
View traditional medical practitioner registration status	The system will allow users to view the application status	Traditional medical practitioner/TAHPC registrar/District executive director/Regional medical officer	User needs to be signed in to the system and applied for registration	Traditional medical practitioner and registrar will view the notification
Add, View, Approve, Update practitioner	The system will provide an option for adding, viewing and approval of traditional medical practitioner application	TAHPC registrar/District executive director/ Regional medical officer	User needs to be signed in to the system User should granted a privilege	Traditional medical practitioner will be viewed, added, and their details will be updated and approved
Issue license to traditional medical practitioner	The license to traditional medical practitioner will be issued	TAHPC registrar	User needs to be signed in to the system User should granted a privilege All defined requirements should be met	Traditional medical practitioner will be granted a license
License expiration notification	The system will generate the notification for license expiration	Traditional medical practitioner/TAHPC registrar	Users should have a valid email Users should be signed in	Users will receive a notification about license expiration

4.4 Functional Requirements Specification

Both user and system requirements for TMK web-mobile application are integrated together in a single description table as shown in Table 5. The description contains the requirement features and specific functional requirements based on each system requirement.

Table 5. User and System requirements specification

Requirements Feature	Requirements Description
Login and logout	**1. The system shall grant access to users** 1.1 The tool shall allow user registration 1.2 The tool shall also offer a self-registration for TMPs 1.3 The system will require user to enter the login details 1.4 Users should only log into the system upon providing correct credentials 1.5 The users credentials shall be authenticated by the system 1.6 Upon failing of users credential, a pop up error message will be displayed, with options to resolve the issue 1.7 Upon login successful, the system will direct the user to the appropriate webpage 1.8 The system will provide the signing out mechanism to users signed in 1.9 User session will be terminated after successful logout
Personalized profile	**2. The system shall provide an option for profile management** 2.1 The tool shall enable users to update their profile 2.2 The system shall allow users to add/upload their images 2.3 The system shall provide the total number of TMK collection added
TMK information configuration	**3. The tool shall allow configuration of plant species information to be performed** 3.1 The tool shall allow upload of family names, genus and species 3.2 The tool shall allow adding scientific authors to the system 3.3 The tool shall allow herbarium information configuration
TMK data upload	**4. The system shall allow user to add TMK data in the system** 4.1 The system shall accept preliminary medicinal plant information 4.2 Users shall update the other information of medicinal plants at any time 4.3 Only users with relevant privileges will update the information 4.4 The system shall allow users to approve the added data 4.5 The system shall allow users to display information to public or not 4.6 The system shall allow multiple data upload or single data entry 4.7 The system shall provide a mechanism for capturing data with corresponding researcher of a certain herbaria
View facility	**5. The System shall provide a view feature of TMK available in the system** 5.1 The tool shall enable users to view available data in the public domain 5.2 The tool shall enable users to download the report with selected data 5.3 The system shall provide the visualization of available TMK data 5.4 The system shall display list of users of the system
TMPs Registration	**6. The system shall allow TMPs application for registration** 6.1 The system shall enable users to apply for registration by the government authority 6.2 The tool shall enable users to approve the application 6.3 The tool shall allow users to send notification to applicant 6.4 The system shall enable applicant to view their application status 6.5 The tool shall be able to print out the certificate for successful applicant 6.6 The tool shall allow enable to upload documents 6.7 The tool shall notify users upon license expiration

4.5 A Proposed Structure of Traditional Knowledge on Medicinal Plants

Based on the user requirements specified, the structure of the TMK management information system was proposed and modelled. It contains medicinal plant information to be captured in the digital tool. The proposed structure of TMK data would be divided into four parts as indicated in Fig. 2. The structure contains traditional knowledge, knowledge sources, scientific information and literature on certain specific medicinal plant.

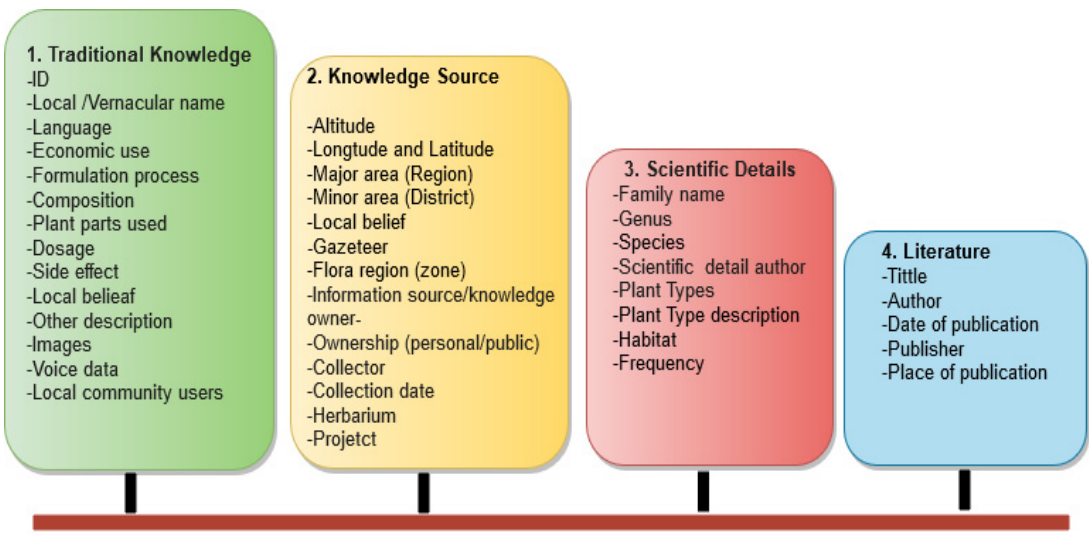

Fig. 2. A structure for TMK information of medicinal plants

4.6 Types of information on traditional medicinal plants

Information on traditional knowledge of medicinal plants that are collected and preserved in the herbarium and those from clients were used to model the structure presented in Fig. 2 and the data types for TMK structure are indicated in Table 6. Traditional knowledge information contains key data items that show the indigenous knowledge about a certain herb, knowledge sources are the information that indicate the origins of such data. Scientific details and literature information show taxonomic information and the corresponding research publications respectively. Table 7 shows an actual example of medicinal plant information as modelled in the structure (see Fig. 2).

Table 6. Data types for Traditional Medical Knowledge

Data Items	Data Types		
	Text	Integer	Date/Timestamp
Traditional Knowledge	Plant ID, Local name, Economic use, Formulation process, Composition, Plant parts used, Dosage, Side effect, Local belief, Other description, Images, voice data, Local community users		
Knowledge Sources	Longitude and Latitude, Major Area, Minor Area, Gazeteer, Flora region, Ownership types, Knowledge owner, Collector	Altitude	Collection date
Scientific Details	Family name, Genus, Species, Plant types and description, Habitat, Frequency, Scientific Author's details		
Literature Information	Tittle, Author, Place of publication, Publisher		Publication date

Table 7. Actual example of medicinal plant information

Traditional Knowledge		Knowledge sources	
Data Item	Data Value	Data Item	Data Value
Plant ID	NHT000006	Longitude and Latitude	3.1833° S, 36.5001° E
Local name	Itoto	Altitude	1680M
Local language	Kimeru	Major Area (Region)	Arusha
Economic use	Abdominal pains / complications due to food poisoning	Minor Area (District)	Arumeru
Formulation process	Leaves are boiled in 1 Litre of water and drunk then vomited to remove the poisoned food from the stomach	Gazeteer	Kilinga
Composition	Water and leaves	Flora region	T2
Plant parts used	Leaves	Knowledge Ownership	Public
Dosage	N/A	Collector	Njau E; Salum Y
Side effect	N/A	Collection date	25 September 2007
Local belief	N/A		
Other description	N/A		
Images			
Local community users	Meru people		
Scientific Details		Literature Information	
Family name	Labiatae	Tittle	N/A
Genus	Tetradenia	Author	N/A
Species	Riparia	Publication date	N/A
Plant types and description	Shrub 2.5 m tall, flowers creamy orange.	Place of publication	N/A
Habitat	Text	Publisher	N/A
Frequency	Common		
Scientific Author's details	(Hochst.) Codd		

4.7 Non-Functional Requirements

Every system operates under certain limitations referred to as non-functional requirements that describe how the application should work and behave. Table 8 indicates constrains under which a web-mobile for TMK stakeholders should operate.

Table 8. A List of Non-functional Requirements

Requirements feature	Description
Accessibility	- The system shall operate under both Swahili and English
Reliability & Availability	- The system shall be made available online all the time under a uniform resource locator (URL)
Usability	- The tool shall have a friendly user interface - The tool shall be compatible to all web browsers - The interface shall bear responsiveness - The system shall involve the use of icons and toolbars
Privacy and Copyright	- The system shall display to the public the knowledge available in the public domain only and knowledge that is personal will remain as confidential - The system shall encrypt users password
Scalability & Modifiability	- The system shall allow easy extension of other features depending on requirements change - The application shall allow a number of growing work and addition of resources - The system shall be adaptable to any herbaria in Tanzania
Security	- The system shall require authentication in any modification of data - The system shall automatically sign out (end session) after inactive time set by user. Secure socket layer (SSL) as used to encrypt the link between server and client - The too shall enable users to perform roles depending on the privilege granted

4.8 Data Flow Modelling

A data flow Modelling is a graphical representation of data exchange between information systems or proceeding elements (Pandey & Pandey, 2012). In this study, the data flow in the proposed TMK management information system was modelled using a context diagram (see Fig. 3) which shows an overview of the how data should flow from the system to its external entity based on inputs and outputs.

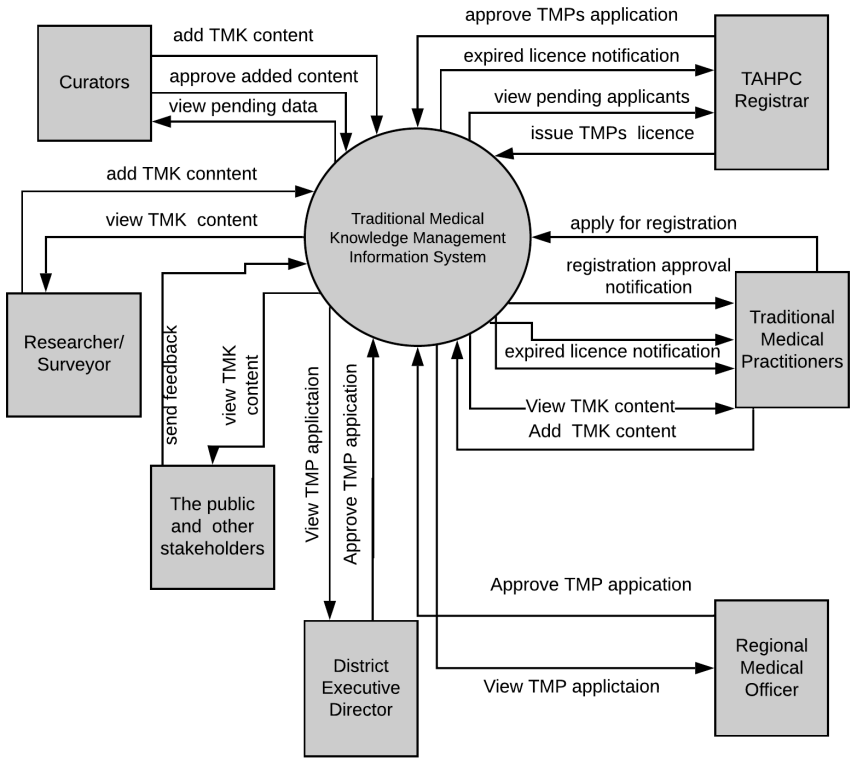

Fig. 3. A context diagram for a proposed TMK web-mobile tool adapted from (Beebwa et al., 2019)

5. Discussion

Information Management with the use of ICTs has massively increased with Technology evolution. ICTs functionalities are highlighted in storage retrieval and dissemination of such information. For instance, available information in herbaria, library and archives, need to be preserved and disseminated to the stakeholders using digital systems. Digital tools for managing information can be highly achieved with well-designed and conducted requirements engineering. In software development, client's needs have to be met to ensure fulfilment of the intent of developing such a software and customer's satisfaction measures the functional and non-functional requirement aspects of it. Software projects may fail if they do not comply with the client's needs due to poorly defined requirements (Gowtham et al., 2017). Clearly defined requirements provide a picture to systems analysts and programmers of what kind of software should be built and what kind of features should be included to meet the intended stakeholder's needs.

Traditional medicine practitioners are among the stakeholders that could need the application of ICT tools to enable them preserve and disseminate relevant information related to the practice of traditional medicine in health care delivery. This is mainly because of the myriad drawbacks characterizing the current methods and approaches used in preserving existing information on TMK. Much

of this information in various communities, is stored and held in the memory of the older generations who oftentimes pass it to younger generations. Such information stand the danger of being lost under the passage of generations as those who own it ether grow older, senile and incapable of communicating whatever information they know or incase the younger generation fail to take up the information due to lack of interest or change of social-economic trends that compel the youths of the day to move away from their birth places. Many countries especially in East Africa where traditional medicine is preferably practiced, have tried to promote knowledge preservation of traditional medicine through the use of herbaria. However, such preservation is done manually making retrieval and manipulation of such data impossible. Moreover, such information is stored with few institutions which are mainly learning and research institutions, making it accessible to very few people and many a time excluding the majority who are practicing traditional medicine in one way or the other.

The high reliability of the majority of the people on TMK especially phytomedicine, and the undeniable role such knowledge is playing in maintaining people's health, calls for alternative means and methods of preserving such knowledge and preferably prevent its possible extinction. Application of ICT tools offers a perfect and reliable means of storing TMK. The use of such tools will not only minimize the possible loss of such knowledge but will also promote easy retrieval and improvement of such information. Moreover, since the use of traditional medicine could portend unprecedented health risks to the users, it would be necessary for the relevant country authorities to regulate the use, practice and application of such knowledge. This can be done through regulated registration and licensing of the stakeholders and the ICT tools can prove indispensable in achieving such registration and regulation processes.

Informed by the relevance and vast application of traditional medical practices and the challenges surrounding the general practice in Tanzania, this study was carried out to establish the attitude of the stakeholders towards the adoption of an ICT tool that can digitize TMK information and eventually circumvent the challenges facing the existing methods of perseveration. The study sought out the opinion of 224 stakeholders pertaining the possible use of a digital platform that could manage the practice of TMK. Majority of the stakeholders that were interviewed showed a positive attitude on adopting the use of digital systems that could manage indigenous knowledge of medicinal plants and relevant practitioners.

Moreover, the interviewed stakeholders were asked to indicate important engineering requirements for any likely proposed digital system they thought could appropriately manage TMK. They indicated both functional and non-functions requirements they could wish such a system to possess. Apart from suggesting a system that will securely and reliably capture the relevant information on medicinal plants, a good number of researchers and practitioners indicated the need to have a designed web-mobile tool operating under both Swahili and English language. This indicated that the stakeholders needed to have a tool that would operate in the local language which they were most comfortable with. Additionally, the stakeholders indicated the need to have a tool that would bear responsiveness and flexibility in any screen size. Indeed, users own diverse devices they use to access internet including computers, smartphone and tablets. Therefore, they wished to have a digital tool that would be compatible to their own devices they are familiar with.

The data collected in this study revealed that various stakeholders of traditional medicine had

a similar view on the functional and non-functional requirements on the proposed web-mobile application. For instance, researchers from Arusha indicated the kind of needs that were similar to those of their counterparts from Dar es Salaam. Although the requirements were expressed in different ways, they all pointed to the same need, thus they were all categorized into one group for documentation. The gathered information from the stakeholders on the functional and non-functions engineering requirements was used to design a model structure for phytomedicine that can be integrated into a digital web application in storing and managing such knowledge.

6. Conclusion

Preserving TMK is very crucial since modern medical innovative solutions can be derived from such knowledge. Moreover, such knowledge has found vast application among communities especially in developing countries where the majority are relying on traditional medicine for their day to day health needs. Digitization of such knowledge will guarantee perpetual storage and general management. This will also alleviate the general drawbacks facing most of the currently existing methods of preserving and managing TMK. This research study presents the initial functional and non-functional requirements that can be used to build a web-mobile application for capturing and documenting TMK on medicinal plants to minimize its extinction and manage practitioners' registration processes in Tanzania. The requirements collected and analyzed from this study examines details of traditional medicine stakeholder's needs which can be extensively used as a guideline for digitizing indigenous knowledge on medicinal plants. However, Prototyping model can be employed during system development for improvement and validation of these requirements through client's feedback.

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