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# Bridging the Digital Divide: Developing Local Digital Heritage Content and Investigating Localized Digital Solutions

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**Abstract:** The digital divide, in my view, is not only created due to the lack of local contents but also due to the fact that few digital contents from local sources are found in the digital libraries of higher education in Ethiopia. Likewise, the creation and dissemination of local contents could be facilitated not only by the presence of local digital contents but also by the presence of usable digital technology at a local level. This article aims to give a practical solution to bridging the digital divide by unlocking local heritage knowledge through creating digital contents from locally grown literary heritage as well as by developing a localised digital library system. Therefore, this article presents the research processes and results that were undertaken to unlock local heritage knowledge and developed the localised digital library system: customising a free and open-source software; digitising and translating the local literary heritage contents; and building the digitised and translated literary heritage contents into the localised digital libraries, which Greenstone digital library software was used to customise into local use. The English version of the Greenstone user interface (macro files) was translated into the Tigrinya language, one of the locally spoken languages in Ethiopia. For translation purposes, a list of suitable and compatible Tigrinya words and phrases that basically fit with the meaning of the English version of the Greenstone spreadsheet was developed. As a result of this translation work, the Tigrinya language interface has become one of the languages that are included in Greenstone digital library software version 2.83 for the first time (Language short name=ti “long name=ትግርኛ (Tigrinya)” default encoding=utf-8). To unlock the heritage knowledge and build the localised digital library with local digital collections, a sample of Ethiopia’s ancient Ge’ez parchment manuscripts were digitised and translated into Tigrinya and English languages. To facilitate the retrieval of information and to be easily recognised by internet search engines in the Tigrinya

language, a local specific metadata standard for Ethiopia’s ancient Ge’ez parchment manuscripts was developed at three hierarchical levels, at manuscript level, at chapter level and at page level, with each translated page tagged using HTML. To facilitate the link between the translated text and the corresponding digital image, an “item” file was created using a WordPad. As a result, three collections were built into the customised digital library: the digitised image of the Abushakir manuscript as well as the Tigrinya and English translated texts of the same manuscripts. The functionality and usability of the localised digital system was tested by searching keywords and browsing titles from the built collection of the Tigrinya text and the original digital image of the manuscript. The result of this test shows that the localised digital library system is capable of allowing end-users to discover the information they want at the granular level from digital content of the local literary heritage. Therefore, further manuscript collection through digitisation, translating into local language and building the digitised collection into this localised digital library system is necessary for wider access to the local literary heritage digital content and for bridging the digital divide in the long-term.

**Keywords:** Ethiopia; Tigrinya; local; heritage; digital content; digital divide

## 1 Introduction

This article presents the processes and results of the localised digital library system that the author developed to make locally grown literary heritage content more accessible and unlock the local heritage knowledge. In this paper, the localised digital library system refers to the system that was developed in Tigrinya language, one of the locally spoken languages in Ethiopia, by translating and customising the Greenstone user interface macro files (for more information about Greenstone software see Witten and Bainbridge 2002). Likewise, the local literary heritage content refers to Ethiopia’s ancient Ge’ez parchment manuscripts. Most of the ancient manuscripts of Ethiopia were inscribed in the Ge’ez language, which was said to be one of the ancient written languages of the world with a complete alphabet and

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numerals different from that of Latin in the Western world (for more information about Ge'ez language see Bekerie 1997; Uhlig 1990; Ullendorff 1960). Today, Ge'ez is not a spoken language in Ethiopia but serves as the liturgical language of the church, while some spoken languages in Ethiopia such as *Tigrinya* and *Amharic* use Ge'ez alphabets and numerals. Our initial aim to develop the localised digital library system for Ethiopia's ancient Ge'ez parchment manuscripts originated from the following fourfold reasons, the first of which is the presence of a large and relevant collection of Ethiopia's ancient Ge'ez parchment manuscripts in various ancient churches and monasteries in Tigray, Ethiopia (Haile 2018). Those collections contain invaluable information which is useful for unlocking the local knowledge systems (Mennasemay 2009; Pankhurst 1999; Taddese 1972). The second is to make those manuscripts accessible and usable to the wider public which are otherwise impossible to access since they are found in remote and inaccessible locations. Third, the current state of physical condition and preservation of the ancient manuscripts is discouraging and hence a new way of ensuring long-term preservation should be put in place. Fourth, we believe that it is time to move in parallel with current digital technology in digitising and accessing ancient literary heritages and bridge the digital divide that existed among those who have no access to digital local heritage contents.

This article hence discusses and presents the development processes and results that are involved to build the localised digital library system to make Ethiopia's ancient Ge'ez manuscript collections available and accessible to the wider community. Specifically, it discusses research processes and experimentation we carried out to develop the localised digital library system. Moreover, it describes the processes that involve Ge'ez manuscript acquisition through digitisation, and the translation of the user interface of the Greenstone software as well as the translation of Ge'ez contents into Tigrigna and English. The digitised and translated manuscript collection was used to build the localised digital library system as well as test the efficiency and usability of the localised digital library system in supporting Ge'ez script, which is the alphabet of the local language, *Tigrinya*. Furthermore, the article also presents the metadata standard that we specifically developed for Ge'ez manuscript heritage. This is followed by the discussion on collection building, enriching the collection with appropriate metadata elements and values, designing the necessary plugin and assign search and browsing classifiers. The remainder of the article is devoted to the presentation of the research results in which the functionality and usability of the localised digital library system was tested in providing

the end-user with user-friendly information retrieval capabilities in a local language, which is *Tigrinya*.

## 2 Theoretical Settings and Statement of the Problem

In today's information landscape, it is commonly viewed that the internet, mobile cell phones, digital libraries and several other new electronic information and communication technologies (ICTs) are opening new pathways for transforming the way we live, work, learn and communicate. However, access to affordable digital library technology and quality information from local contents remains a fundamental problem in today's global information markets. The digital divide (see Brown 2018; Harrison and Raine 2018, for its definition) in my view, is not only created due to the lack of local contents but also because little digital content from local sources can be found in the digital libraries of higher education in Ethiopia, for instance. Likewise, the creation and dissemination of local content could be facilitated not only by the presence of local content but also by the presence of usable and affordable digital technology at a local level. In order to contextualise my argument, I present here two complementary theories related to the digital divide and their possible solutions, the medium theory and the knowledge gap hypothesis theory (as cited in Iddi, Justus, and Caroline 2014). While the medium theory holds the view that social and political power is wielded through control over communication media, the knowledge gap hypothesis theory suggests that each new medium increases the gap between the information rich and information poor because of differences in access to the medium, and control over its use, among other factors. From such a problematic situation about the means of accessing information and the relevance and quality of the information itself, one can easily understand that no single theory can sufficiently and critically address this. A significant number of scholars agree that digital libraries have a huge potential towards balancing the knowledge discrepancy in many parts of the world (Igum 2013; Kavulya 2007; Ogunmodede et al. 2023). While the significance of digital libraries is exemplified in this manner, it is also reasonable to critically see the relevance of content creation and preservation at a local level through digitisation and make them accessible through digital technology (see Akinde 2007; Ballantyne 2004; Cartelli and Palma 2009; Chen et al. 2005; Chiware 2007; Ross 2007; Sadanand 2008; Thiyam 2008). Therefore, it can be argued that moving toward a synchronised and practical approach is required in order to minimise the digital divide and, therefore,

developing a localised digital library system and digitising local contents are imperative in this regard.

However, at the threshold of the information age, libraries and museums in Ethiopia are unable to connect people with their relevant historic and cultural heritage. While the importance of Ethiopia's ancient literary documents has often been raised in national and international published literature (Liuzzo 2019; Nosnitsin 2013), concrete initiatives to preserve them physically in their original places and/or to create access to the wider community through digitisation and digital library technology are very hard to find (Haile 2018). In Ethiopia, for example, ancient Ge'ez manuscripts have not been the subject of systematic inquiry with respect to digital preservation and accessibility to the wider community. As a result of this gap, there is little information about the specific relevance of the ancient Ge'ez manuscripts to the socioeconomic aspects of Ethiopian people (Mennasemay 2009; Pankhurst 2010; Wion 2006). Added to this problem is that there is also a tendency to limit the function of the ancient manuscripts to mere religious services and therefore they have been marginalised for a long period of time. Even though such literary heritage has the potential to bridge the digital divide, they are not accessible to the wider community.

And yet the need for the systematic digital preservation and accessibility of Ethiopian manuscripts that are found in various ancient monasteries, churches and mosques of Ethiopia is greater than ever before. In recent decades, the emergence of higher educational and research institutions such as colleges and universities in Ethiopia has contributed the greatest demand to thoroughly and systematically study the relevance of ancient Ge'ez manuscripts to the people of Ethiopia and the need to apply digital technologies to promote long-term preservation and accessibilities. The development of contents from local sources like ancient Ge'ez manuscripts and utilisation of these contents through appropriate digital library technology could yield important information that could play a significant role in improving people's knowledge of secular life, for instance minimising the digital divide that exists in the global information marketplace. Therefore, this article gives a practical solution to bridging the digital divide by creating digital contents from locally grown literary heritage as well as by developing a localised digital library system.

### 3 Objectives

The main objectives of developing the localised digital library for Ethiopia's ancient Ge'ez manuscript are to:

- preserve the contents that are contained in the original manuscripts on a long-lasting medium through digitisation and digital library technology
- improve access by enabling the use of the contents of the original manuscripts in digital forms that cannot be consulted in their original physical form
- improve the digital library service to an expanding user group by providing enhanced digital access to the country's ancient literary heritage
- reduce the handling and use of fragile or heavily used original physical manuscripts and create a "back up" copy for endangered collections and ensuring their long-term preservation and
- bridge the digital divide by unlocking the local heritage knowledge and giving the local community access to local information in their own local language

## 4 Methods and Processes

### 4.1 Selection of and Customising the Greenstone Digital Library Software

#### 4.1.1 Selecting the Greenstone Digital Library System

In the current digital information landscape, there are many versions of free and open-source software (FOSS). Among them are Greenstone, Fedora, DSpace, Koha and ABCD, to mention a few. However, each such open-source software has different features and is initially developed for different purposes. For instance, DSpace is a platform to build and preserve an Institutional Repository where authors submit their publications so that collections are searchable and retrievable via the Web (Madalli 2003). Koha, another software, is an integrated library system designed to provide the Online Public Access Catalogue (OPAC) module. Whereas the Greenstone digital library system is a comprehensive system designed for building and distributing digital library collections (Witten 2009), the main aim of Greenstone software is to empower users, particularly in universities, libraries and other public service institutions, to build their own digital libraries as Greenstone incorporates an interface that makes it easy for people to create their own library collections as well as preserve the endangered indigenous languages and heritages (ibid). Besides, Greenstone provides metadata-based browsing facilities and allows users to modify or develop their own collection specific metadata. Moreover, it has UNICODE based multi-lingual capabilities, and there are also Greenstone support staff under the language maintainer group in Waikato University Digital Library Project, New Zealand.

#### 4.1.2 Customizing and Translating the English Version of the Greenstone User Interface into Tigrinya Language

After having chosen the Greenstone software for localizing the digital library system, the next task was to translate the English version of the Greenstone user interface (macro files) into the Tigrinya language. This was followed by translating both the Auxiliary and Core Macro Files of the Greenstone user interface into Tigrinya, but before we did this, we completed two important steps: firstly, receiving the English version of the Greenstone spreadsheet from the Waikato University Digital Library Project, New Zealand; and second, identifying the Tigrinya words and phrases that are compatible with the English version of the Greenstone user interface. We thus sourced the local language standard from the Ethiopian Telecommunication Agency and used this local language standard as the base reference, but we improved many of the Tigrinya words and phrases to make them suitable and compatible with the words and phrases of the English version of the Greenstone spreadsheet. After securing both the English version of Greenstone interfaces and the Tigrinya language standard that is compatible with the English version, we translated the entire auxiliary and core macro files of the user interface of the Greenstone software. As a result of this, the Tigrinya language interface became part of the languages that are included in the Greenstone digital library software version 2.83 for the first time. In the subsequent versions of Greenstone, Tigrinya is embedded in the Greenstone software and available to all users. For our contribution we are recognised by the

Greenstone language developers and maintainers and the name of the author of this article has been included in the language maintainers' group list for the Tigrinya language on the Greenstone website.

In following Tables 1 and 2, we provide some samples of Tigrinya translated strings of the user interface of core and auxiliary files of Greenstone.

#### 4.1.3 Making Tigrigna Language Part of the Greenstone Working Languages

After completing the translation work of the core and auxiliary files of the Greenstone user interface, we sent the spreadsheet to the Greenstone language maintainer team at Waikato University, New Zealand for further evaluation. After having processed the spreadsheets, Anna (our correspondent for the Greenstone language maintainer team) sent us the operational files in the form a zip archive. To install them, we unzipped the operational file and then put the tigrinya.dm and tigrinya2.dm files into the macros folder of the Greenstone installation. We opened the “main.cfg” file in the etc-subfolder of the Greenstone folder and then searched the language names that begin with the letter “T”.

We found the following line:

```
turkish.dm turkish2.dm ukrainian.dm urdu.dm urdu2.dm \
```

and changed it to

```
tigrinya.dm, tigrinya2.dm turkish.dm turkish2.dm ukrainian.dm  
urdu.dm urdu2.dm \.
```

**Table 1:** Sample translated auxiliary files.

|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| source::docs_textnodocumentation_ | <p>&lt;p&gt;This Greenstone installation does not include any documentation. This may be because:</p> <p>&lt;ol&gt;</p> <p>&lt;li&gt;Greenstone was installed from CD-ROM using a compact installation.</p> <p>&lt;li&gt;Greenstone was installed from a distribution downloaded from the internet.</p> <p>&lt;/ol&gt;</p> <p>In either case you may obtain the documentation either from the &lt;i&gt;docs&lt;/i&gt; directory of a Greenstone CD-ROM or by visiting &lt;a href="http://www.greenstone.org"&gt;http://www.greenstone.org&lt;/a&gt;</p> |
| target::docs_textnodocumentation_ | <p>&lt;p&gt;እዚ ግሪንስቶን መትከል ምንም ሰነድ ሓበሬታ ኣይሓዘን። ምክንያቱም</p> <p>ምናልባት፤</p> <p>&lt;ol&gt;</p> <p>&lt;li&gt;ግሪንስቶን ዝተሃነጸ ካብተነባቢ ሲዲ ብኮምፓክት መትከል ብምጥቃም እዩ።</p> <p>&lt;li&gt;ግሪንስቶን ዝተሃነጸ ኣብኢንተርኔት ዝሰራጨዉ ብምወራድ እዩ።</p> <p>&lt;/ol&gt;</p> <p>ዝኮነኩይኑ እቲ ሰነድ ሓበሬታ ካብ &lt;i&gt;docs&lt;/i&gt;</p> <p>ማህደር ወይም ካብተነባቢ ሲዲ ወይም &lt;a href="http://www.greenstone.org"&gt;http://www.greenstone.org&lt;/a&gt;</p> <p>ብምብፃሕ ምርካብ ይከኣል እዩ።</p>                                                                                                                           |

**Table 2:** Sample translated core files.

```

<ul>
  <li>To search for documents about a single year:<p>
  <ul>
    <li>Type in any ordinary search terms as you normally would.
    <li>Type the year you want into the “Start (or only) date” box.
    <li>If your date is from before the common era (also known as before
      Christ), choose the “B.C.E” option from the pull down menu next to
      that box.
    <li>Begin your search as you ordinarily would.
  </ul>
</ul>
<p><li>To search for documents about a time period or range of years:<p>
  <ul>
    <li>Type in any ordinary search terms as you normally would.
    <li>Type the earlier date into the “Start (or only) date” box.
    <li>Type the later date into the “End date” box.
    <li>Select “B.C.E” option from the pull down menu next to any date
      from before the common era (also known as before Christ).
    <li>Begin your search as you ordinarily would.
  </ul>
</ul><p>
  <ul>
    <li>ብሔረ ዝተወሰነ ዓመት ዘለው ሰነዳት ንምእላሽ፤<p>
    <ul>
      <li>ከምትልመድ ናይኣለሻ ቃል ኣእትው።
      <li>እትደል ዓመት “ናይመጀመሪያ (ወይም ጥራሕ) ዕለት” ብዝተባላ ሰነድ
        ውስጥ ኣእትው።
      <li>ከእተካ ዕለት ቅድሚ ልደተ ክርስቶስ እንተኮይኑ “ዓ.ዓ.” (“B.C.E”) ዝብል
        መማረቂ እቲ ዕለት ኣብ ትሕቲ ዝእተካሉ ሰነድ ካብዘሎ ዝጉተት መምረቂ ውሽጢ
        ምረቅ።
      <li>ቅድሚ ሕዚ ኣብመደበኛ ኣለሻ እዋን ከምእትገብሮ ኣለሻ ጀምር።
    </ul>
  <p><li>ዝተወሰነ እዋን ዝሸፍኑ ወይም ኣብሞንጎ ዓመታት ዘለው ሰነዳት
    ንምእላሽ፤<p>
    <ul>
      <li>ከምትልመድ ናይኣለሻ ቃል ኣእትው።
      <li>ናይቅድሚ እዋን “ናይመጀመሪያ (ወይም ጥራሕ) ዕለት” ኣብዝተባላ ሰነድ
        ውሽጢ ኣእትው።
      <li>ንሕዚ ዝቀርብ እዋን “መወዳእታ ዕለት” ኣብዝተባላ ሃፁን ውሽጢ
        ኣእትው።
      <li>ንቅድሚ ልደተ ክርስቶስ ዝኮኑ እዋናት “ዓ.ዓ.” (“B.C.E”) ዝብል መማረቂ
        ዕለት ኣብዝእተካሉ ሰነድ ቀዳላ ካብዘሎ ዝጉተት መምረቅ ዝርዝር ውሽጢ ምረቅ።
      <li>ቅድሚ ሕዚ ብመደበኛ ኣለሻ እዋን ከምእትገብሮ ኣለሻ ጀምር።
    </ul>
  </ul><p>

```

We then found this line:

```
Language short name=th; Long name=Thai default encoding=utf-8
```

and added the following line after it: Language short name=ti “long name=ትግርኛ (Tigrinya)” default encoding=utf-8

These changes to the “main.cfg” file add the configuration for the Tigrinya language. After restarting the Greenstone

server, one now can switch to Tigrinya in the Preferences page. Finally, we viewed the Greenstone homepage of the user interface in *Tigrinya*, and at the same time viewed the user interface in *Tigrinya*. Users can switch to the English interface by choosing it with the language preference button (Figures 1–4).

## 4.2 Digitising and Translating of Sample Ge'ez Parchment Manuscripts

### 4.2.1 The Digitisation Processes

In order to obtain digital content of Ethiopia’s ancient Ge’ez manuscripts we digitised some sample manuscripts. These digitised contents were used to build the collection into the localised digital library system and to test its capabilities in providing seamless searching and browsing capabilities in Tigrigna language. In fact, the prototype also functions in the English language, and digitisation thus facilitates acquisition of contents in digital form and processing the digital data (Britz and Lor 2003). To have quality images and ensure further image processing activities, we saved images in RAW and TIFF file formats. These images are master images that resulted from the direct image capture and are mainly used for further processing of the image in the JPG file format. Adobe Photoshop image editor was used to compress the size of the images, e.g., to render them easily accessible by internet search engines. Each image is given a file name and ID; for example, the first image for the English version of chapter 1 and page 1 of the *Abushakir* Ge’ez manuscript is named “Abushakir\_en\_ch1\_0001”, whereas for the *Tigrinya* version it is named አቡሻክር\_ቲግ\_ቀ1\_0001.

### 4.2.2 Translating the Digitized Ge'ez Documents into Tigrinya and English

Today, the Ge’ez language is no longer a spoken language in Ethiopia. However, it continues to serve as the language of the church in the Orthodox Christian Church in Ethiopia. Except for a few church educators, the majority of Ethiopian people cannot speak and read Ge’ez documents. Translating these relevant documents into *Tigrinya* was thus needed to enable the majority of people to read and understand the information and knowledge contained in Ethiopia’s ancient Ge’ez manuscripts. To push the information and knowledge within the Ge’ez documents into the international information network, it was also deemed necessary to translate these documents into English as well. While some sample Ge’ez manuscripts (*Abushakir* and *Gadala Ahaw*) are translated

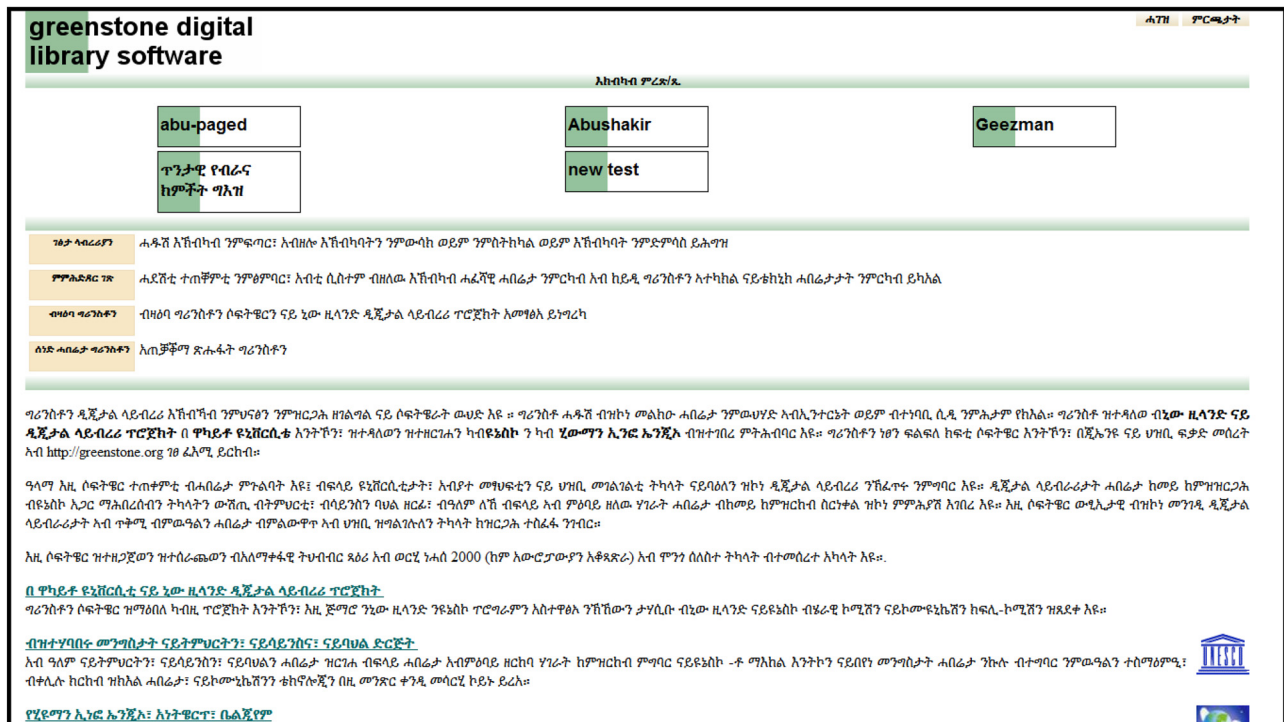


Figure 1: User interface in Tigrinya.

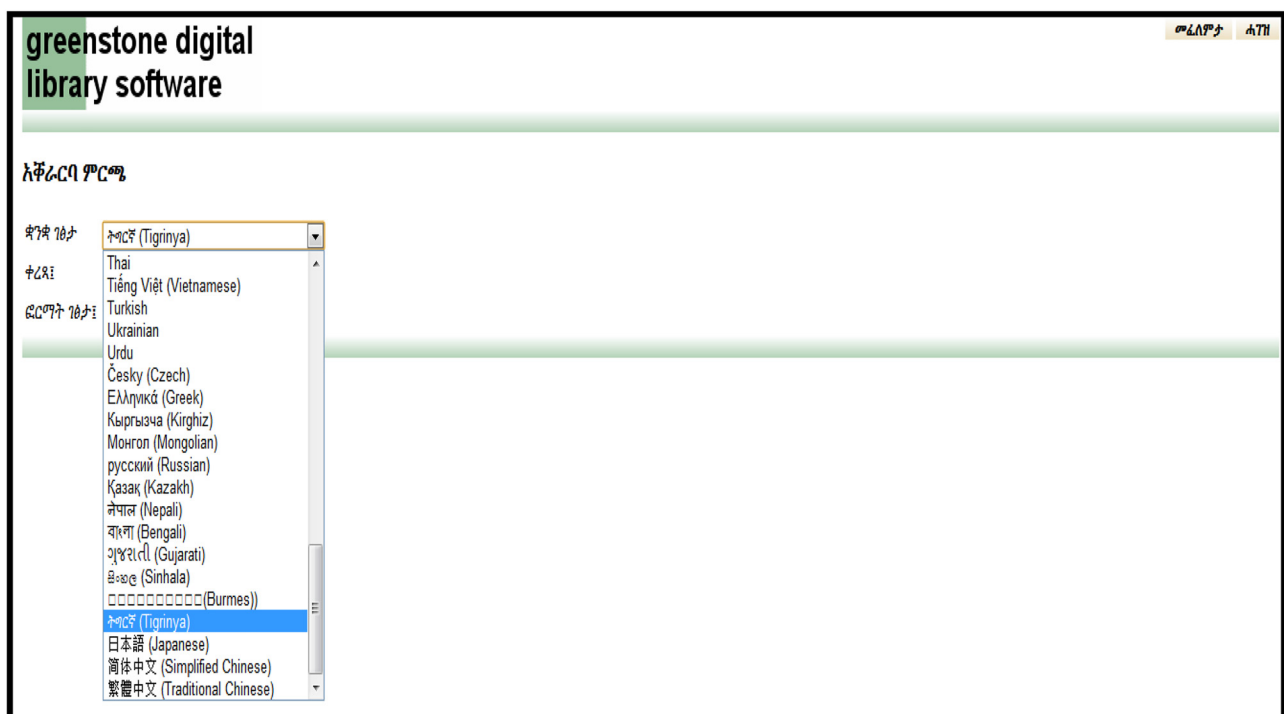


Figure 2: Lists of language preferences where Tigrinya is highlighted.

into *Tigrinya*, only one manuscript was translated into English for the purpose of this article. After translating the Ge'ez documents into *Tigrinya* and English we continued to

localise the Greenstone display page by creating a header image with its source names. We created an image file as a banner with its source names, saved the image as

**Geezman**

Interface language:

Encoding:

Interface format:

**Search preferences**

Query mode: ☒ simple query mode  
☐ advanced query mode (allows boolean searching using !, &, |, and parentheses)

Query style: ☒ normal with  query box  
☐ fielded with  fields

Search history: ☒ do not display search history  
☐ display  search history records

Return up to  hits with  hits per page.

Figure 3: Presentation preference in Tigrinya.

**Geezman**

Interface language:

Encoding:

Interface format:

**Search preferences**

Query mode: ☒ simple query mode  
☐ advanced query mode (allows boolean searching using !, &, |, and parentheses)

Query style: ☒ normal with  query box  
☐ fielded with  fields

Search history: ☒ do not display search history  
☐ display  search history records

Return up to  hits with  hits per page.

Figure 4: Presentation preference in English.

“banner\_bg.jpg” and put it into the “Greenstone/collect/Abushakir/images” directory. The result of this change is shown in the following figures (Figures 5–7).

Finally, we succeeded in including *Tigrinya* into the Greenstone digital library software as well as altering the default display of the Greenstone user interface into *Tigrinya*. Therefore, we continued to build the manuscript

collection in *Tigrinya* and enriched the collection with metadata at three hierarchical levels, at manuscript level, at chapter level and at page level. Metadata specific to *Tigrinya* language was required to discover information in *Tigrinya* through searching and browsing possibilities. We discuss the process that involves developing *Tigrinya* specific metadata in the following sections.

**Figure 5:** Advanced search interface in *Tigrinya*.

**Figure 6:** Simple search interface in *Tigrinya*.

**Digital Library Collection of Ancient Geez Manuscripts**

HOME SEARCH TITLE SUBJECTS HELP English

Search in  , sorting results by  for  of the words

Return up to  hits with  hits per page.

[Advanced Search](#)

**About this collection**

Abushakir collection

The complete collection comprises 2 subcollections. Those currently available are:

ጥንታዊ የሳራና ክምችት ግእዝ  
Abushakir

You can check (and alter) which subcollections you are currently using on the Preferences page.

**How to find information in the Abushakir collection**

There are 3 ways to find information in this collection:

- search for particular words that appear in the text by clicking the Search button
- browse documents by Title by clicking the Title button
- browse documents by Subject by clicking the Subjects button

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Figure 7: Simple search interface in English.

### 4.3 Developing a Metadata Model Specific for Ethiopia's Ancient Ge'ez Manuscripts

Why do we need specific metadata for Ge'ez manuscripts?

As the digitisation of and access to digital local content is a recent phenomenon in Ethiopia, there is no standard metadata for local digital contents. It is generally thought that it is unrealistic to think that records from every system can be converted to a common standard that will satisfy both general and domain-specific user needs as the number of metadata standards continues to grow (Woodley 2008). Therefore, it is necessary to develop metadata elements by adopting from the existing metadata element sets and schemas to support the needs of specific communities and offer a search interface that allows users to search and retrieve the information at a high granularity level. While metadata creation is one of the core activities of any collecting and memory institution (Baca 2008), it is not an easy task.

For this study, we used the Dublin Core metadata elements as the basis metadata standard. This is mainly because Dublin Core metadata elements are embedded in

the Greenstone software. Moreover, Dublin Core (Witten 2009) was designed to provide a very widely accepted mechanism to allow discovery with the option for different communities of users to adopt and customise it by adding more fields of particular importance to the community (Pasquinelli 2002). However, Dublin Core has no elements to describe the colophon and marginalia of ancient handwritten manuscripts, and we thus also adopted the metadata schema that was developed for searching for information in Arabic manuscripts (see El Banny et al. 2009). We adopted this type of metadata schema because it was developed to enrich the ancient Arabic manuscript which is very similar to our study on the ancient Ge'ez manuscript (Table 3).

However, we also added new metadata elements that are specific to Ethiopia's ancient manuscripts. Our metadata is different from that mentioned above in the conceptual framework of our document organisation and the subsequent development of metadata elements. We organised our document into three hierarchical levels: at manuscript level, chapter level and page level. In this work we use the term metadata to refer to information or value that we add to each metadata element to describe both the translated texts and

**Table 3:** The basic 15 Dublin Core metadata elements (source: Witten 2009).

| Dublin Core metadata elements | Definition                                                                                                                                             |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Title                         | The name given to the resource by the creator or publisher                                                                                             |
| Creator                       | The person or organisation primarily responsible for the intellectual content of the resource                                                          |
| Subject                       | The topic of the resource                                                                                                                              |
| Description                   | A textual description of the content of the resource                                                                                                   |
| Publisher                     | The entity responsible for making the resource available                                                                                               |
| Contributor                   | A person or organisation (other than the creator) who is responsible for making a significant contribution to the intellectual content of the resource |
| Date                          | A date associated with the creation or availability of the resource                                                                                    |
| Type                          | The nature or genre of the content of the resource                                                                                                     |
| Format                        | The physical or digital manifestation of the resource                                                                                                  |
| Identifier                    | An unambiguous reference that uniquely identifies the resource within a given context                                                                  |
| Source                        | A reference to a second resource from which the present resource is derived                                                                            |
| Language                      | The language of the intellectual content of the resource                                                                                               |
| Relation                      | A reference to a related resource, and the nature of its relationship                                                                                  |
| Coverage                      | Spatial location and temporal duration characteristics of the content of the resource                                                                  |
| Rights                        | Information about rights held in the resource                                                                                                          |

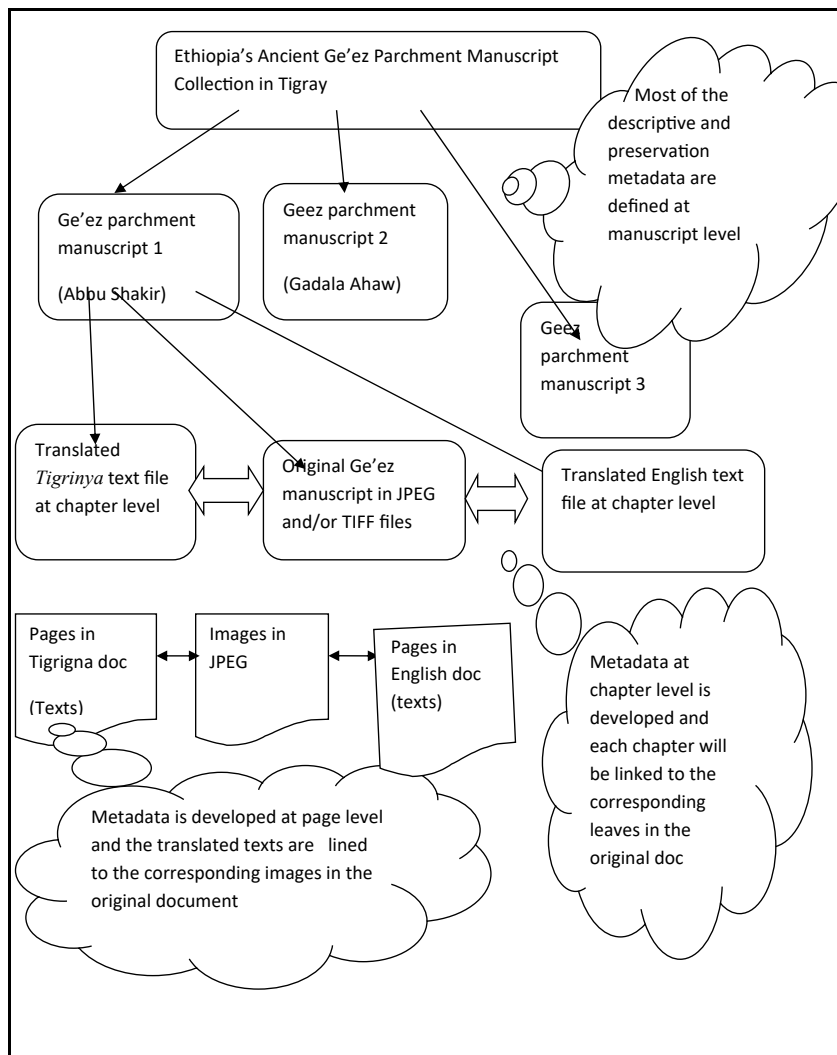
**Figure 8:** Conceptual framework for organising the Ge'ez manuscript collection and metadata hierarchies.

image file. We used these metadata elements to fill out the metadata value for the two sample manuscripts, namely Abushakir and Gadala Ahaw; it is assumed that such metadata ensures effective information retrieval and makes relevant information easier to find by describing an information object. We employed a method of description that exploits item-level metadata for digitised manuscripts so that users can search for specific items on chapters, sections and pages at high-granularity (or “resolution”) levels. The metadata are developed by envisioning the concepts and terms that are likely to be sought by users of digital documents. In writing on the importance of identifying important terms and concepts, Weinberg (2009) suggests that it is necessary to express those concepts and terms that are likely to be sought by users and provide cross-references from synonyms and alternative spellings as well as links to related terms to assist users in finding all the information that is relevant to their topics of interest. In the following, we present the conceptual model for organising the Ge’ez

manuscript collection and metadata hierarchies. Figure 8 below shows the conceptual framework for organising the Ge’ez manuscript collection and metadata hierarchies.

As can be seen from Figure 8 above, the translated Ge’ez manuscript contains information which is logically organized into manuscripts, chapters, and pages. The pages are just containers of information or knowledge which are conceptually related to each other, and information may flow to the next page(s). Such organisation of contents is necessary to create links between each page of the translated *Tigrinya* and English versions and the original image of the document. Therefore, the documents are organised into three major hierarchies. At each hierarchical level, metadata are developed. Descriptive and preservation metadata are given much emphasis, but metadata, such as those that are administrative and technical, are also developed in addition to the metadata elements that are already provided by the Dublin Core Standards. Metadata values are manually pulled out from each chapter and page of the document and added

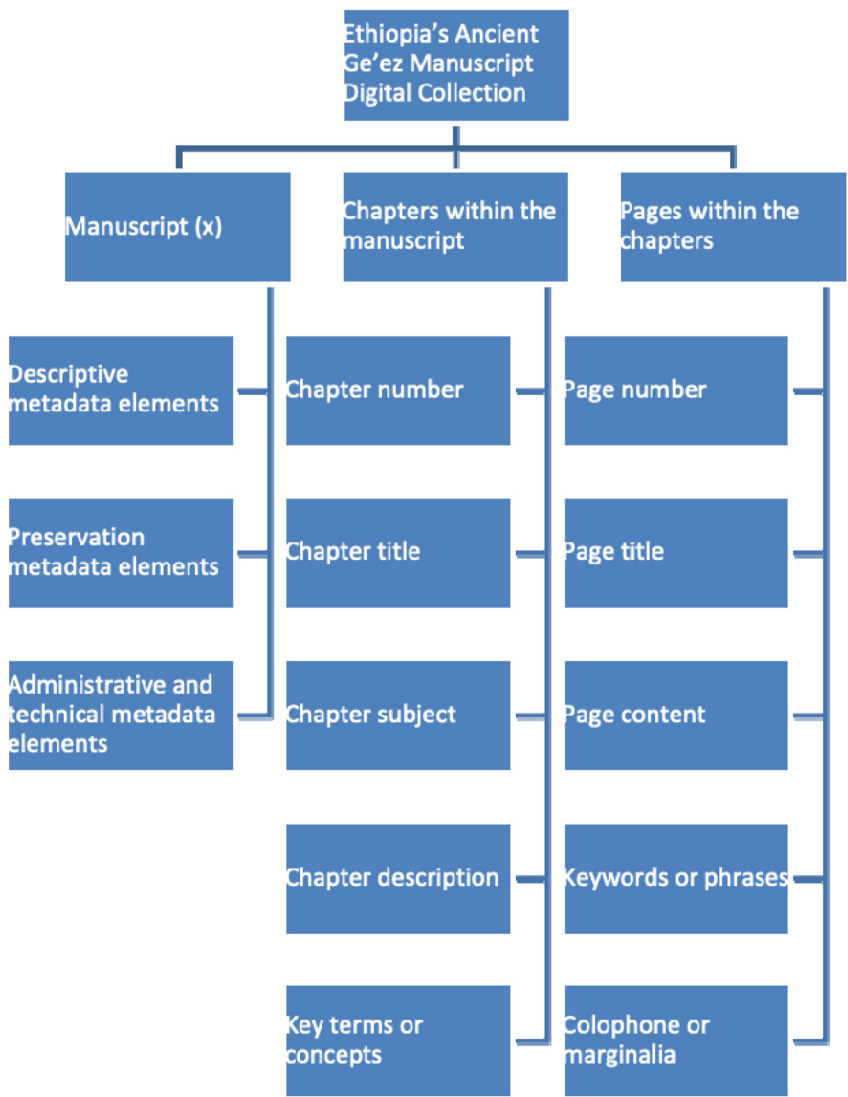


Figure 9: Metadata schema for Ge’ez manuscript collection.

as a value in the specific metadata elements that are prepared for this purpose. These values are unique features that are added to enable end-users to search for and retrieve the information relevant to the query at such a high granularity level. The metadata is then developed by envisioning the concepts and terms that are likely to be sought by end-users. Moreover, these value adding efforts also facilitate the search process by creating a match between the terms used by the indexer and the searcher, while the metadata elements and descriptors are also helpful for preservation purposes. We present the metadata elements that are developed for Ethiopia's ancient Ge'ez manuscripts in Figure 9 below.

## 5 Discussion of Results

### 5.1 Building the Ge'ez Manuscript Digital Collection in the Localised Digital Library

#### 5.1.1 Preparing the Digital Collection and Tagging Using HTML

We prepared the digital content of *Abushakir* Ge'ez manuscript in two formats: image and text. There are two texts, the *Tigrinya* and the English translated text of the *Abushakir* Ge'ez manuscript. The original image of the Ge'ez manuscripts is prepared in JPEG format. To facilitate the retrieval of information and to be easily recognised by internet search engines, each translated page is tagged using HTML by the help of Macromedia Dreamweaver 8, with HTML chosen instead of other tagging and text encoding standards like TEI for several reasons. Firstly, HTML is the standard part of the Greenstone software. Secondly, there are packages like Dreamweaver to facilitate the tagging and encoding system. Thirdly, HTML is closely related to the objective of the project because it has a pre-defined set of presentation semantics, meaning that its specification prescribes how the structure data will be presented. In what follows we present a tagged page of the translated version of *Tigrinya* and an English version, as well as the corresponding original digital image of the same page in the *Abushakir* Ge'ez manuscript (Tables 4 and 5).

We assigned the same file name to each translated page and corresponding image. For example, page one of chapter one is named as follows (Figures 10 and 11):

- English translated version of “Abushakir” Ge'ez manuscript: Abushakir\_en\_ch1\_0001
- The *Tigrinya* translated version of “Abushakir” Ge'ez manuscript: አቡሻክር\_tig\_ch1\_0001

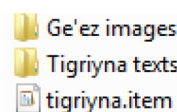
**Table 4:** HTML tagged page (page 5 of chapter 1) in *Tigrinya* text.

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>አቡሻክር_0005</title>
</head>
<body>
<p>ክልተ እንተተረፉ ማርቆስ ፣ 3 እንተተረፉ ሉቃስ ማዕረ ተክይኑ ዮሐንስ ምዚኑ
ይፍለጥ ። በዙይ ወንጌላውያን ሻድሽይቲ ጳጉሜን ትርከብ ።</p>
<p>ወንጌላውያን ዝጅምርሉ ዕለት መን ከምዝኮነ ንምፍለጥ ዓለም
ካብዝተፈጠረሉ ዕለት ጀሚሩ ክሳብ ባሕቲ መስከረም ዘሎ መዓልቲ ተቆፂሩ ብ7 7
ይግበጥ ። 1 ተተረፉ ሮብዕ፣ 5 ተተረፉ ሐሙስ ፣ 6 ተተረፉ ዓርቢ ፣ 7 ተተረፉ ቀዳም
ይኸውን ።</p>
<p>ናይ ጥንተ (ናይ ፀሐይ ጥንተ ፍጥረት ፣ ፀሐይ ዝተፈጠረትሉ) ነገርውን
ከምዙይ'ዩ ። ፀሐይ ዝተፈጠረትሉ መዓልቲ ሓደ ኢሉ ዝቆፀር ኣሎ። ነቶም 3 ዕለታት
ገዲፉ ካብ ረቡዕ ተለዒሉ እንተተቆፀረ ከምኡ ይኸውን ። 1 ተተረፉ ሮብዕ፣ 2 ተተረፉ
ሐሙስ ፣ 3 ተተረፉ ዓርቢ ፣ 4 ተተረፉ ቀዳም ፣ 5 ተተረፉ እሁድ (ሰንበት) ሸዳሽተ
ተተረፉ ሰኑይ ፣ 7 ተተረፉ ሰኑይ ይኸውን ።</p>
<p>ኣስተውዕል! እዙይ ንምግባጥ ሓደ ዘመን ብ7 ብ7 እንተገበጥዎ (እንተገበጠ)
365 ዕለት ኮይኑ 1 ይተርፍ። ካብ 2ይ 1 ካብ 3ይ 1 ካብ 4ይ ዘመን ግና 366 ኮይኑ 2
ይተርፍ። ከምዙይ ገይሮም እንተቆፀርዎ(እንተቆፀረ) ካብ 4 ዘመን 5 መዓልቲ ካብ 8
ዘመን 10 መዓልቲ ፣ ካብ 16 ዘመን 20 መዓልቲ እናበሉ ይግብጥዎ። ካብ 77 ዝተፈረ
1 ተተረፉ ሰንበት (እሁድ) ፣ 2 ተተረፉ ሰኑይ ወዘተ እናበሉ የስልሖም ወይድማ 1
ተተረፉ ሮብዕ ፣ 2 ተተረፉ ሐሙስ ወዘተ እናበሉ የስልሖም።</p>
<p>ሠረገላ ፀሐይ ንምፍለጥ (ፀሐይ ትጓዳዘሉ (ትኸይሉ) ናይ ዓመት ሠረገላ 24 'ዩ።
ንሕድሕድ 2 ወርሒ ኣለዎ።</p>
</body>
</html>
```

- The original image of the “Abushakir” Ge'ez manuscript: Abushakir\_0001.jpg

To facilitate this link between the translated text and the corresponding image, an “item” file had to be created. To create the “item” file, we opened a WordPad, and we grouped/mapped the pages of the images and the corresponding text pages. For example, the “item” file for *Tigrinya* is as follows:

Finally, the collection grouping looks like this:



After creating the three documents (the image, text and item file), we saved them in the “import” folder of Greenstone 2.48 (we found the “import” folder by clicking Greenstone 2.48, “collect” and then the name of the collection, Abushakir, followed by the “import” folder). The collection was then ready for the importing and building processes.

**Table 5:** HTML tagged page (page 5 of chapter 1) in the English text.

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Abushakir_0005</title>
</head>
<body>
<p>If the remainder is 2, it is the era of Mark, and the era of Luke if the
remainder is 3, but if there is no remainder (0), it is the era of John. When the
remainder is zero, the number of days in the 13th month (P'agumen) is
always six (6).<br />
To know the day when an evangelist starts of rule the year, you add all the
days from the evolution of the world to 1st Meskerem of that year, and
divided to seven (7); if the remainder is 1, the day is Wednesday, when the
remainder is 5, the day will be Thursday, Friday when the remainder is six
(6), and if the remainder is 7(seven), the day is Saturday. <br />
There is also another way, which starts from when the sun was created, by
ignoring the three days (Sunday, Monday, and Tuesday). Based on that,
when the remainder is 1, the day is Wednesday, if the remainder is 2, the
day is Thursday, when the remainder is 3; the day is Friday; when the
remainder increase, the day is the next day up to Tuesday: if the remainder
is 7, the day will be Tuesday. <br />
N.B when you divide 365 days for 7, the remainder will be 1 in the first three
years, but the remainder is 2 in the fourth year. Through this process, you
get 5 days' remainder from four years, 10 days from 8 years, 20 days from
16 years. Etc ... the sun has 24 wagons in a year (two wagons in every
month). </p>
</body>
</html>

```

## 5.1.2 Running the Greenstone Librarian Interface

We downloaded the Greenstone digital library software (GSDL) from <http://www.greenstone.org> and then installed the GSDL version 2.84 (Windows version) on our computer. While installing the software, we chose the default options in the installation wizard. We used the Greenstone Librarian Interface (GLI) in order to build our new digital library collection; GLI, a component of the Greenstone digital library software, allowed us to collect the documents, assign metadata and build the documents into a digital library, and even convert the digital document into a CD-ROM library. Specifically, we used GLI to perform the following basic activities when we built up our sample collection:

- Gather documents for building up the collection,
- Enrich the documents with appropriate metadata standards,
- Design the collection, its appearance and access (browse/search) facilities,
- Format the appearance of the digital library,
- Create the collection-importing system and build the collection,
- Convert the digital library into a CD-ROM library, and
- The actual use of Greenstone

First, we started the Greenstone Librarian interface as follows:

**Figure 10:** Image of folio 5 in the Abushakir Ge'ez manuscript.

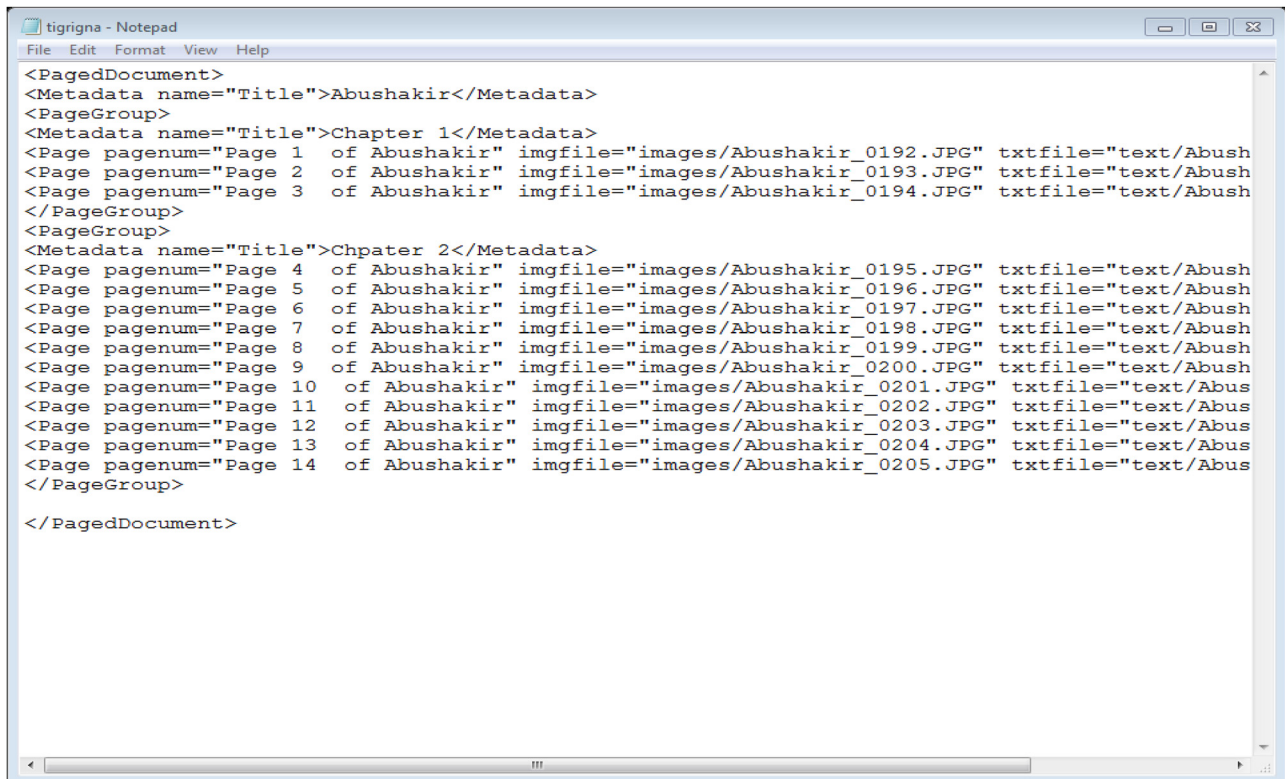


Figure 11: *Tigrinya* item file and its metadata.

Start → All Programs → Greenstone-2.84 → Librarian Interface (GLI)

After a short pause a start-up screen appeared, and then after a slightly longer pause the main Greenstone Librarian Interface appeared. A command prompt was also opened in the background as the Java console (GLI is a Java applet). We then started a new collection within the Librarian Interface:

File → New

A window popped up where we wrote the Collection title and Description of content, which we filled with the name of the

collection: *Abushakir*. We also described the content and left the setting for this collection on its default, New Collection, and clicked “OK”. The processes of creating a new collection can be seen in Figure 12 below.

### 5.1.3 Gathering and Building Collection

After we created the new collection under the folder name “Abushakir”, we gathered the collection using the left-hand side of the Librarian Interface’s “Gather” panel, where all documents within the computer will be displayed. Since our

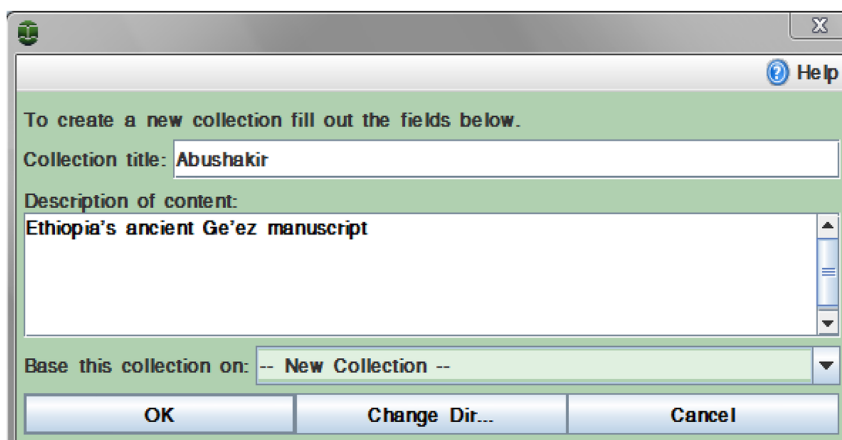


Figure 12: Windows for creating “New Collection”.

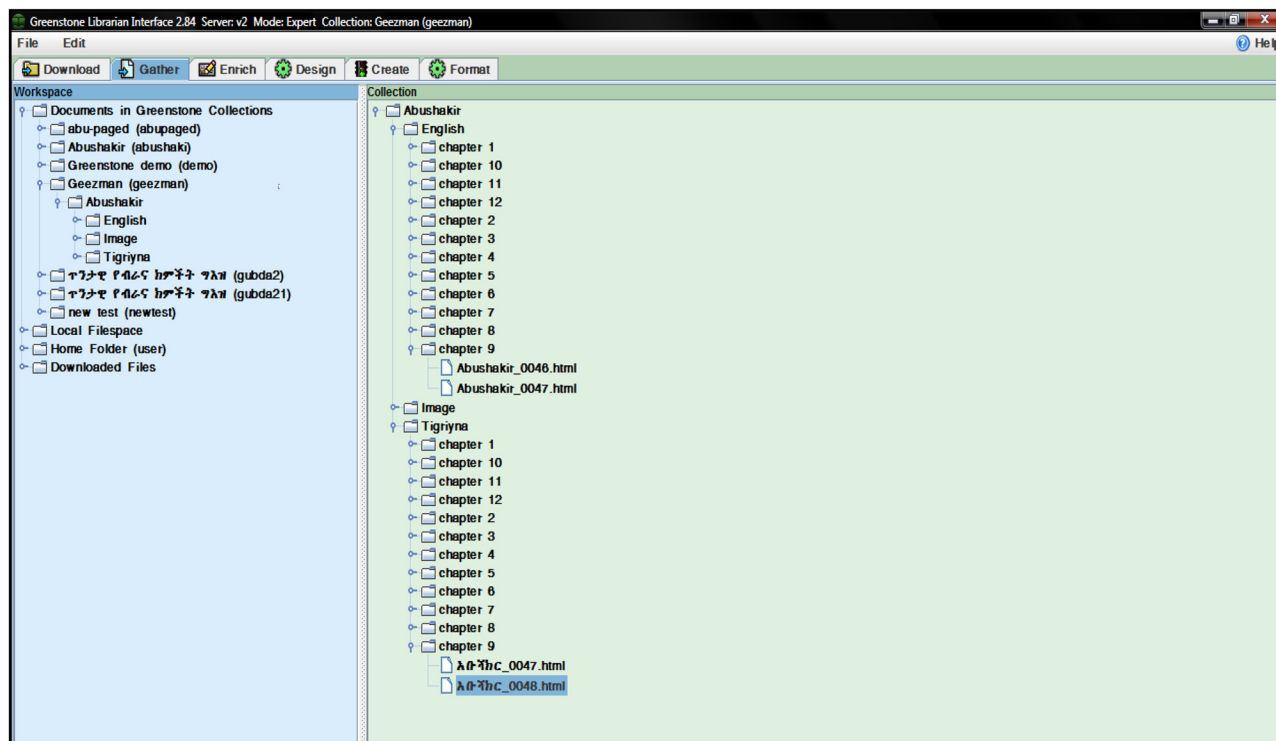


Figure 13: Gathering and inspection folders.

collection was saved within the “Greenstone collects” folder, we opened this folder to choose the *Abushakir* collection folder. The *Abushakir* collection folder, in its “import” folder, contains translated texts, images and “item” files of *Abushakir* Ge’ez manuscripts, with the text file in *Tigrinya* and English languages. The collection under the *Abushakir* folder is organised in three hierarchies: at manuscript, chapter and page levels. We then dragged the *Abushakir* folder from the left-hand side of the Gather panel and dropped it on the right side, and inspected the files that were dropped by double-clicking on the folder on the right-hand side. Figure 13 below shows the gathering and inspection processes.

The “Create Panel” helps to import and build the collection. We used the “Create Panel” to build the collection for further document processing like enriching the document using metadata standards. Figure 14 below shows the process of building the gathered collection.

#### 5.1.4 Enriching the Collection

We used the “Enrich” panel to add values for the metadata elements that we have already prepared for Ge’ez manuscripts, and enriched or enhanced the collection by selecting individual documents and manually adding metadata. We

used the option “manage metadata set”, which is the Greenstone editor for metadata sets, to create a metadata standard for Ethiopia’s ancient Ge’ez manuscript collection at three hierarchical levels, namely manuscript, chapter, and page (Figure 15).

#### 5.1.5 Designing the Collection

The “Design” panel facilitates the following designing processes.

- Adding the necessary document “plugin” such as PageImagePlugin, HTMLPlugin, PDFPlugin and WordPlugin. These and many more plug-ins are found in the “Document plugin” by clicking on the Design panel of the Greenstone user interface.
- Defining the search indexes such as dc. Title, dc. Description, dc. Creator, dc. Subject, etc. These and many other search indexes are found by clicking on the “Design” panel. It is also necessary to choose one indexer from the given alternatives. The indexers are: MGPP, MG and Lucene.
- Adding browsing classifiers such as Titles, Creators, Subjects, etc. The browsing classifiers allow us to browse contents/information from the letter “A” to “Z”. Adding

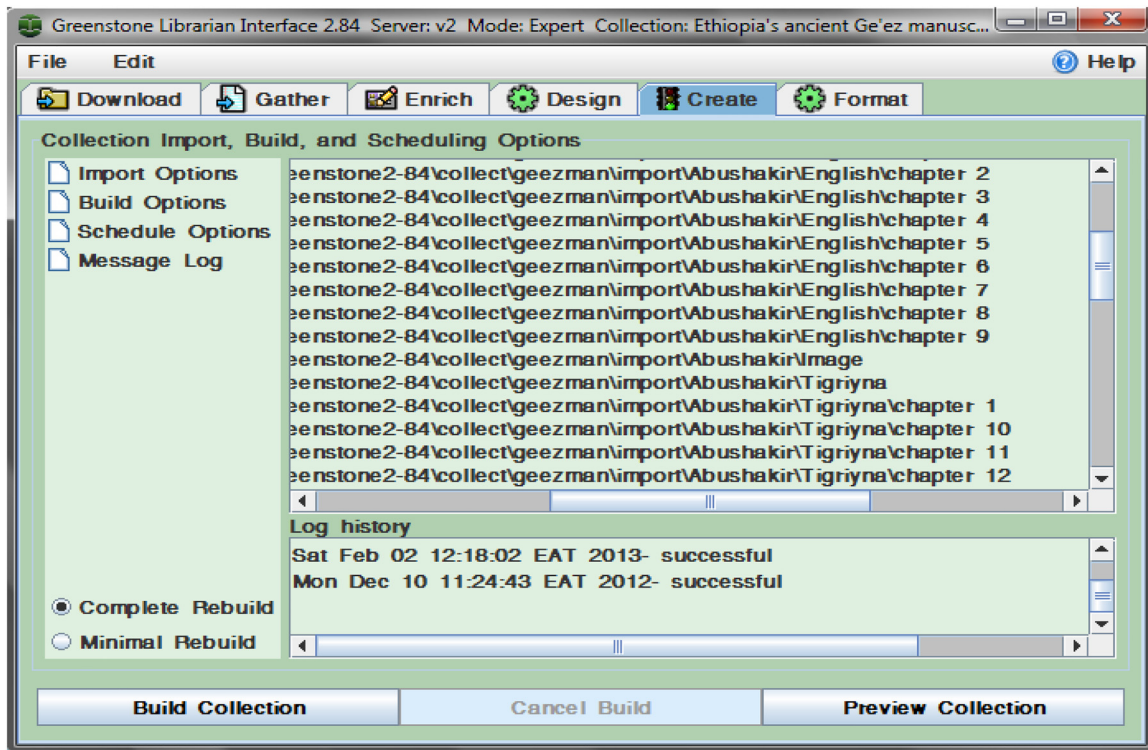


Figure 14: Importing and building collection in progress.

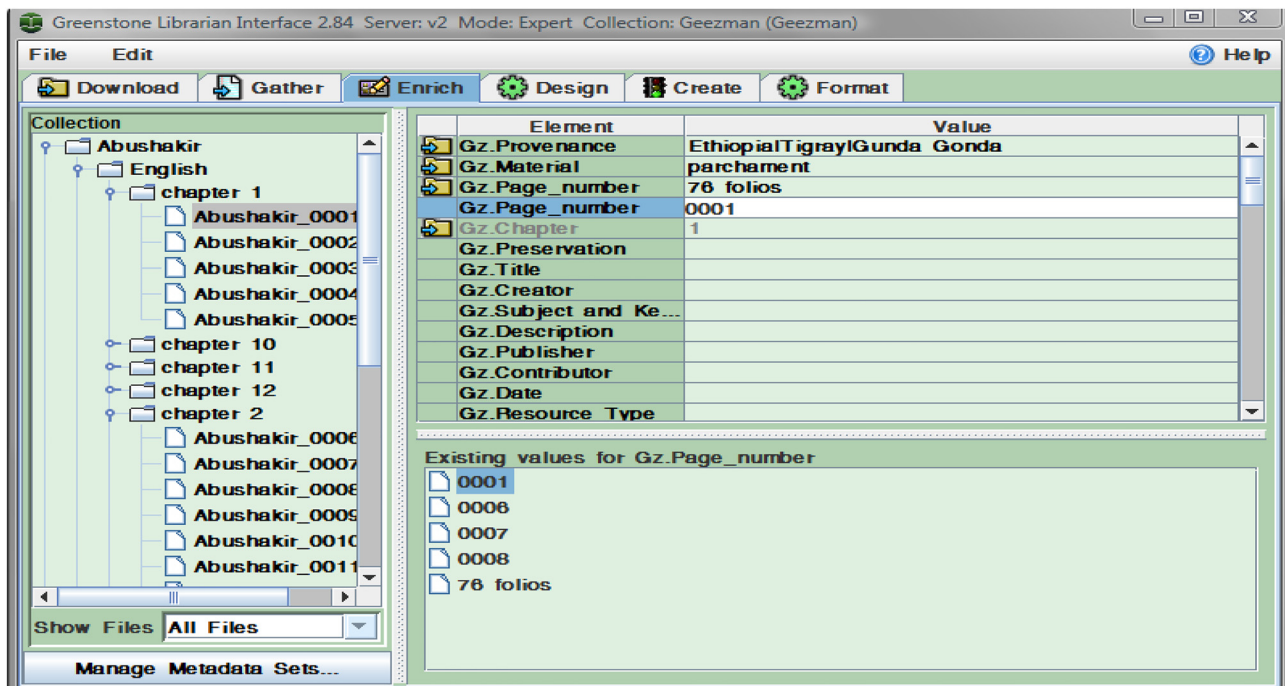


Figure 15: Enriching documents with metadata.

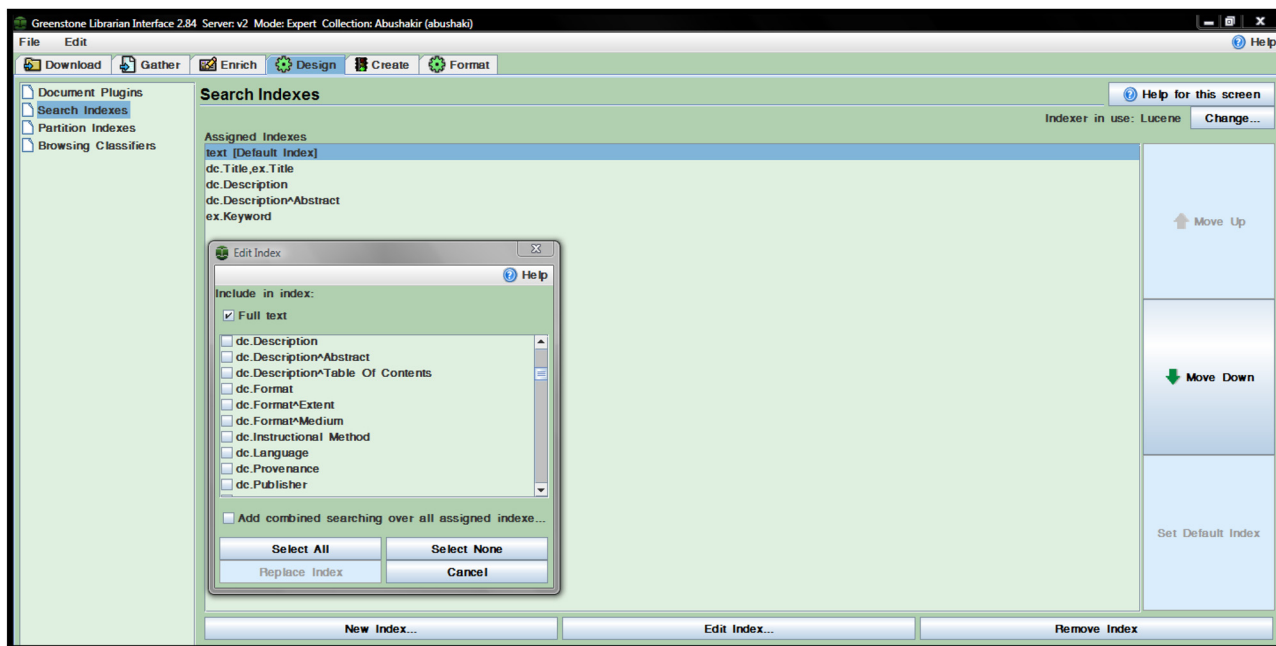


Figure 16: Search indexes under the “Design” panel.

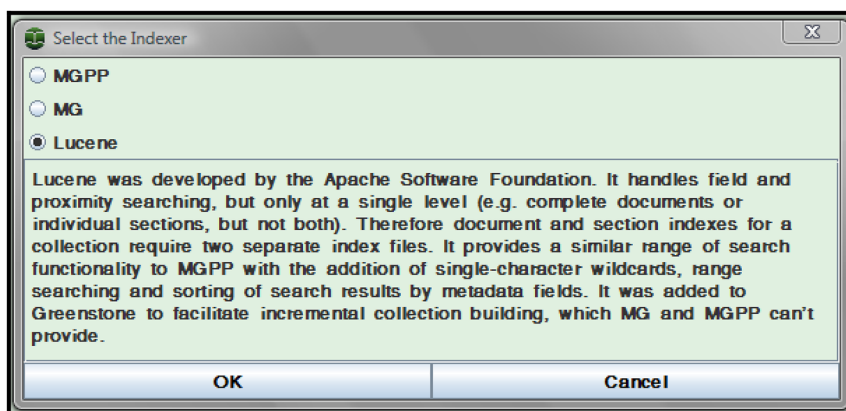


Figure 17: Indexers under the “Design” panel.

different browsing classifiers helps to have an A–Z compact list of the build collection and its extracted metadata.

The following two screenshots show some of the design processes (Figures 16 and 17).

### 5.1.6 Formatting the Collection

The “format” panel is used to change the appearance of the user interface pages of Greenstone. We changed the appearance or the display Greenstone page by translating texts that require “HTML” code as an argument like the following:

```
{If}{[dc.Title],<b>አርእስት: [dc.Title]}<br>
{If}{[dc.Title'alternative],ተለዋጠ ስም : [dc.Title'alternative]}<br>
{If}{[dc.Subject],ጥንጥ መፅሃፍ : [dc.Subject]}<br>
{If}{[dc.Date'created],<b>ገዛዊ ስድስት : [dc.Date'created]} <br><br>
{If}{[srcicon],[link]Document information[/link]}

{If}{[dc.Type],<td style="border-bottom: 1px solid Green;
background-color: #eee;">ጥንጥ መፅሃፍ:</td> <td style="border-bot-
tom: 1px solid Green;">[dc.Type]</td>}

</tr>
```

```

<tr>

{If}{[dc.Coverage`spatial],<td style="border-bottom: 1px solid
Green; background-color: #eee;">መጠቀሚያ ቦታ:</td> <td style="border-
bottom: 1px solid Green;">[dc.Coverage`spatial]</td>}

</tr>

<tr>

```

The “Format” features also include adding, configuring or removing metadata sets in the collection and what elements they contain. Therefore, we formatted the features of our localised digital library by translating texts into *Tigrinya* language as well as specifying collection specific macros such as language, header name, banner image, package query (advanced and simple search) options, etc. The following two screenshots show some of the format features that we used to localise the digital library system (Figures 18 and 19).

### 5.1.7 Testing the Functionality and Usability of the Localised Digital Library System

We built three collections, i.e., the digitised image of *Abushakir* manuscript, the *Tigrinya*, and English translated

texts of the same manuscripts. We tested the search ability of contents by keyword and phrases as well as the browsing capabilities of the localised digital library system in *Tigrinya* (Figures 20–22).

## 6 Conclusion

In this article we presented research processes and results that involve developing a prototype localised digital library system in *Tigrinya language*. We successfully customised the greenstone digital library software and made *Tigrinya* language part of the greenstone working languages. And hence, we localized the digital library system by translating the auxiliary and core file of the greenstone interface into *Tigrinya*. We also developed specific metadata for Ge’ez parchment manuscripts to promote the discoverability of the collection in the digital library as well as on the internet. We also digitised sample Ge’ez manuscripts and translated them into *Tigrinya* and English languages. We organised the digitised and translated documents into three hierarchical levels, namely manuscript, chapter, and page. To create the link between the translated version and the original image of the Ge’ez manuscripts, we assigned each translated page

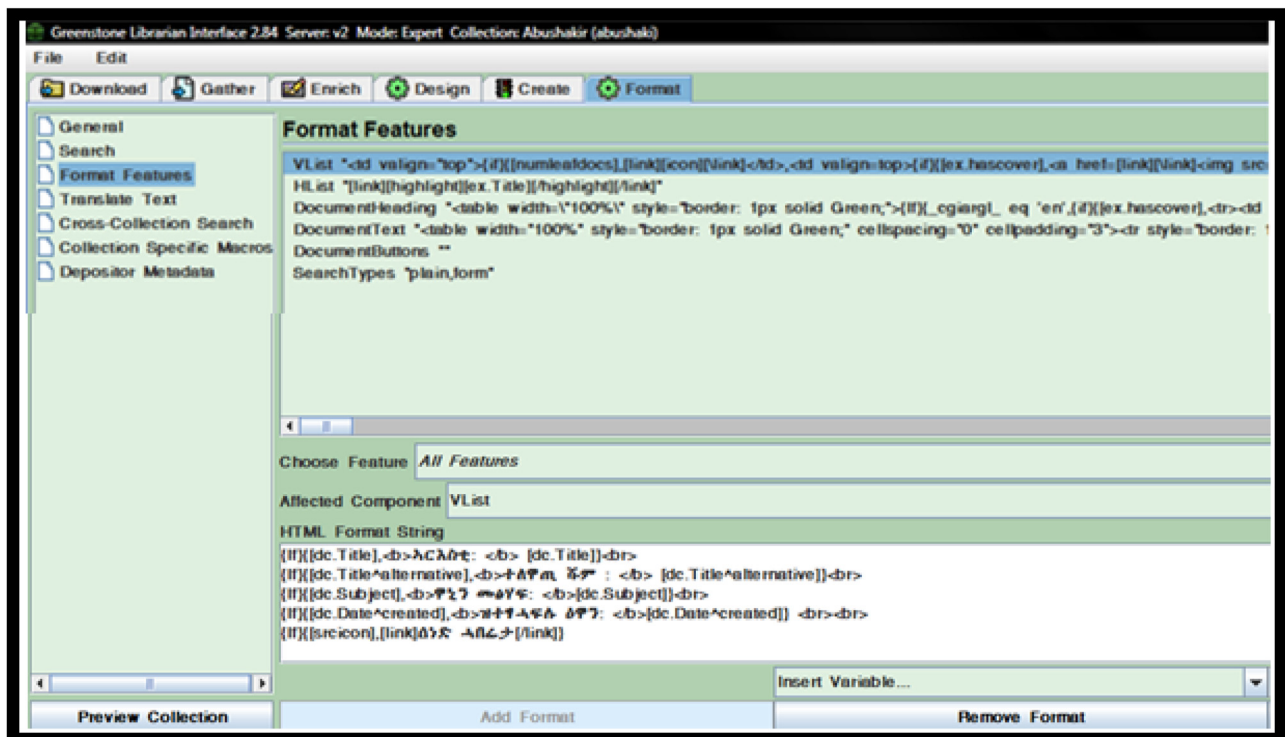
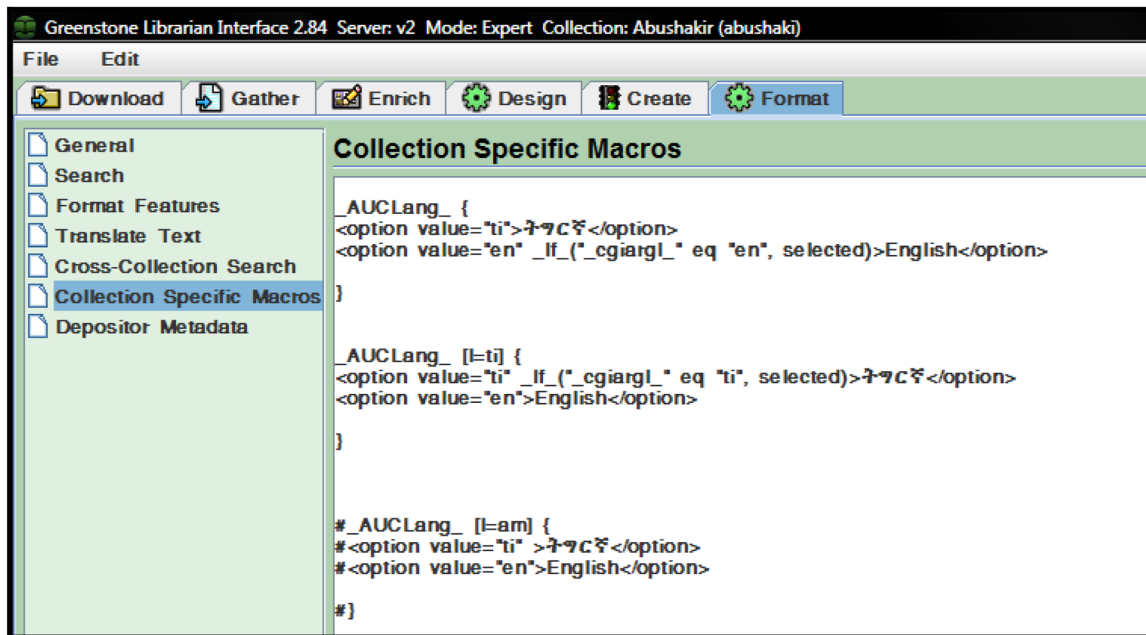
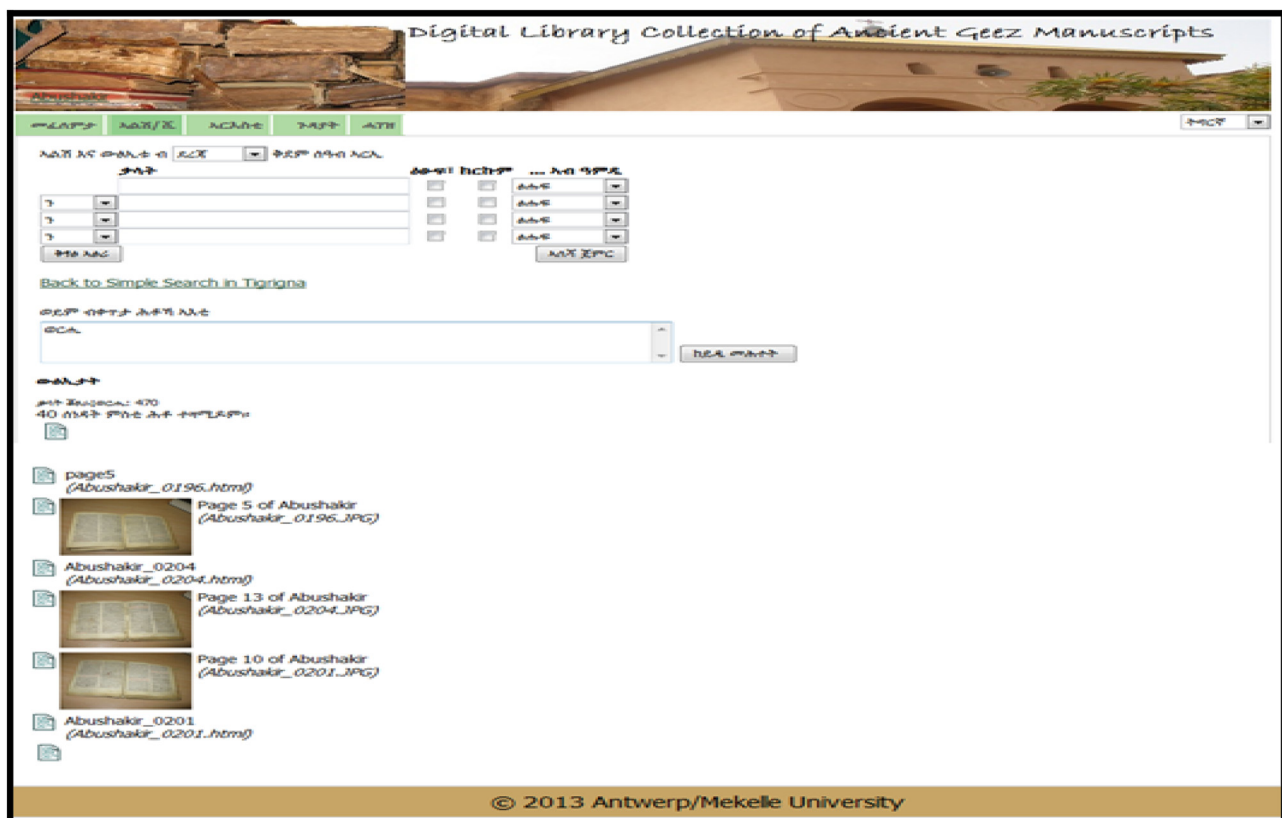


Figure 18: The format features under the “Format” panel.



**Figure 19:** Collection specific macros in *Tigrinya*.



**Figure 20:** Search result at page level for the keyword “འཇུ་ཁུ་” both from the translated *Tigrinya* text and from the original digital image of Abushakir manuscript.

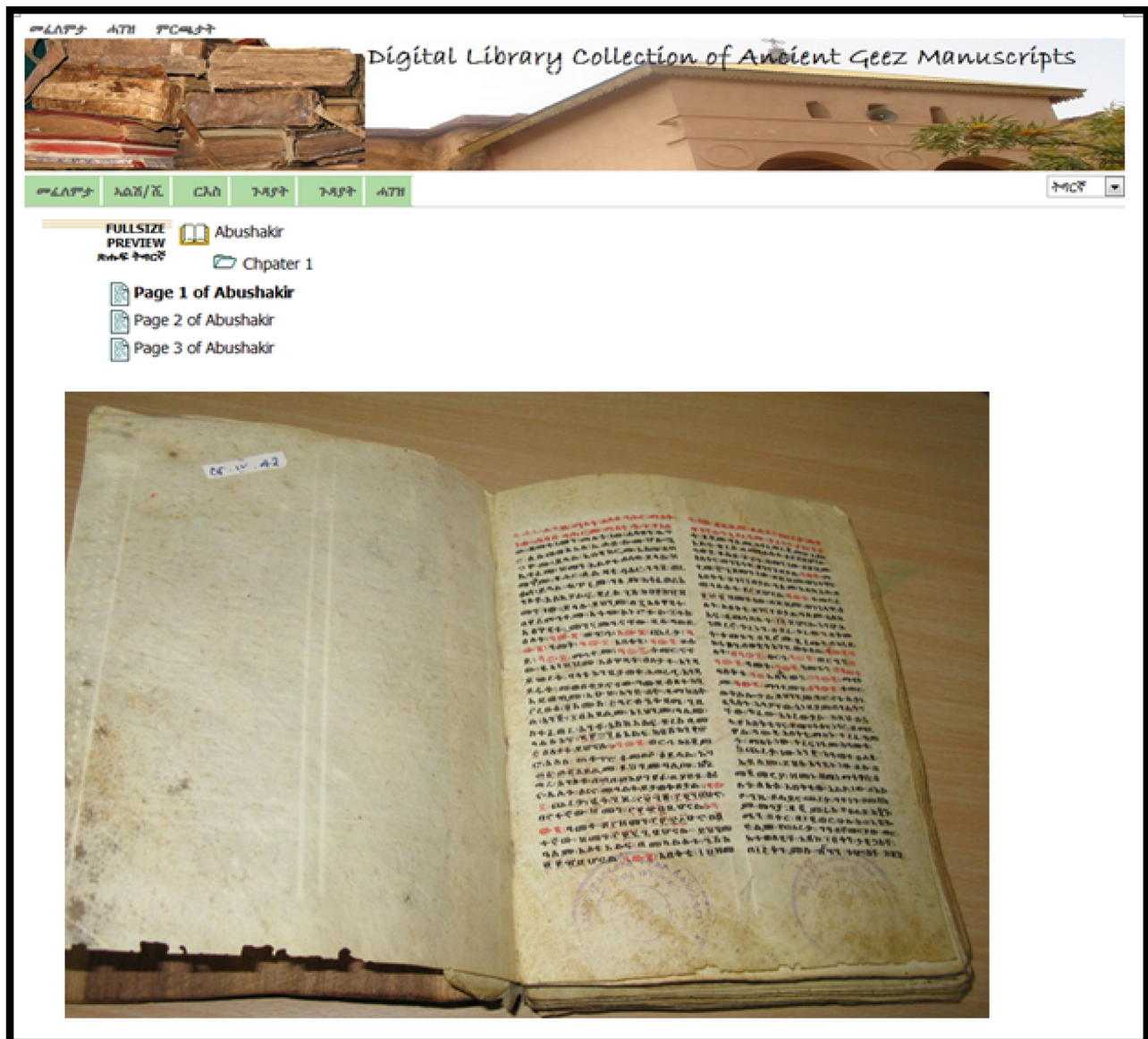


Figure 21: The link between the text and the image of the same page.

and corresponding image the same file name. To facilitate the retrieval of information and to be easily recognised by the internet search engines, each translated page is tagged using HTML by the help of Macromedia Dreamweaver 8. We tested the functionality and usability of the system by searching, using keywords, and browsing subject titles. The test result shows that the localised digital library can provide access to end users with the information they need from the digital content of the local literary heritage at page level using their local language, i.e., Tigrigna, as well as the original digital image of the manuscripts. We are also anticipating that the localised digital library system will work for large collections and facilitate our attempt to

unlock heritage knowledge and bridge the digital divide that existed among those who do not have access to locally grown knowledge. However, the digital collection built in this localised digital library contains a small number of manuscript collections. We suggest that gathering more manuscript collections through digitisation and building the collection into this localised digital library is necessary to render more access to Ethiopia's ancient Ge'ez parchment manuscript contents. Finally, we conclude that this article gives a practical solution to bridging the digital divide by creating digital contents from locally grown literary heritage as well as by developing a localized digital library system.



Figure 22: Search result at page level from the translated *Tigrinya* text.

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