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Contents

1	Acknowledgments	3
2	Executive summary	4
3	Introduction	5
4	Project objectives and structure	6
5	Methodology	7
6	Updating and expanding the technical information of tropical forages	8
7	Enhancing access to and delivery of knowledge on tropical forages	10
8	Tropical Forages – the prototype	13
9	Product release, communication and dissemination	15
10	Outlook on the future	16
11	Conclusions and recommendations	17
11.1	Conclusions.....	17
11.2	Recommendations.....	17
12	References	18
12.1	References cited in report.....	18
12.2	List of publications produced by project.....	18
13	Appendixes	19
13.1	Appendix 1:	19
13.2	Appendix 2:	19

1 Acknowledgments

Our team: Tropical Forages (formerly known as SoFT) is the result of the work of a small team of experienced tropical forage scientists building on a foundation of the same name created through extensive sourcing of tacit and published knowledge by a much larger group in a project terminating in 2005. CSIRO was the lead agency for that project, supported by the then QDPI, now DAF, in Queensland, Australia, as well as CIAT (now the Alliance of Bioversity International and CIAT, ABC) in Colombia and ILRI in Kenya. We would like to acknowledge the immense effort put in by that original project team, and the generosity of CSIRO in signing over its portion of the Intellectual Property Rights to CIAT (now with 2/3 of IP rights) so they could coordinate and maintain the new database, with the continued support of ILRI (with 1/3 of IP rights) and the CGIAR Research Program on Livestock. The product is fully open access.

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2 Executive summary

The availability of quality forage and livestock feed, particularly in times of feed scarcity, remains one of the key constraints to increasing livestock productivity in the tropics. The use of well-adapted, improved sown forages underpins the development of sustainable livestock production systems and natural resource management. Selection of Forages for the Tropics (SoFT; <http://tropicalforages.info/>) is an open-access, online, expert knowledge system created by a team of renowned international forage specialists between 2000 and 2005. It provides detailed information on 180 major forages grown in the tropics and sub-tropics and incorporates a species selection tool based on target environment and forage use. The ability to select and prioritize forages for specific production niches, environments, socio-economic conditions and specific animal requirements is important to mitigate feed shortages and improve natural resource management as part of sustainable farming systems. Since its release in 2005, SoFT is being used by a wide range of actors, with an average of >250,000 website visits and >175,000 unique visitors per year. Although those numbers are impressive, research has advanced during the last 10-15 years and generated new information on forage performance and use. At the same time, rapid advances in knowledge management and information technology were made, such as the use of mobile devices and automatic translation features.

Updating the original SoFT tool to a new, improved version ("Tropical Forages" from here on), was proposed to ACIAR as SRA project in 2016 and funded from 2017-2019. The aim of this project was to enrich Tropical Forages both in terms of content and technical features, in order to enhance its quality, utility, usability and reach. Through a series of workshops, meetings and literature review, this project consulted with a group of scientists who provided global leadership to tropical forage research and development for the last 30 to 40 years. By this, the following outputs were achieved:

- 1) Updating and improving tropical forages knowledge: All species were revised regarding their adequacy and obsolete species were deleted/new ones added, leaving 172 species in the new tool. The respective species factsheets were updated in terms of scientific knowledge, photos and cultivar/accession information. Missing factsheets were developed and added. The selection tool was updated regarding its functioning and selection criteria and all new species were incorporated.
- 2) Improving access to tropical forage information: The tool website was updated in terms of technical advances and optimized for tablets and smartphones. In addition, a mobile application was developed. The design of the website was renewed, and a pdf-download function for all factsheets, automatic google-translation for 30+ languages, and a user feedback mechanism were added.

The prototypes of the new Tropical Forages website (<http://bit.ly/SoFT-Test>) and mobile app (<https://tinyurl.com/rxjevle>) are already available and currently in the final testing phase. Due to the COVID-19 pandemic, the final testing meeting had to be postponed for now and a change of location was necessary (from China to Australia). The project team also decided to wait with the official launch until the crisis has calmed down and adequate attention and media coverage can be given to the release.

After the release of the new tool, we expect to reach even more users than with version 1, in particular in regions where access to information is granted mostly via mobile phones and tablets, e.g., Sub-Saharan Africa, East Asia and Central America and the Caribbean. Through providing a mobile application, we also hope to attract younger users. The added translation functionality is expected to further increase reach.

3 Introduction

Global demand for meat, milk and eggs is expected to double by 2050, with the largest increases expected in developing countries (Rosegrant et al., 2009). At the same time, there is an increased concern on healthy diets and from sustainable food systems, requiring not only a shift of dietary patterns but also more sustainable ways of production (Lancet commissions, 2019). Forages are commonly the most cost-effective option to supply feed demands, particularly for ruminant livestock, but also for pig and poultry production. They are also central in the sustainable intensification of mixed crop-forage-livestock-tree systems. Sustainable intensification not only improves the productivity of tropical forage-based systems but also reduced the ecological footprint of livestock production and generates a diversity of ecosystems services such as improved soil quality and reduced erosion, sedimentation and greenhouse gas emissions (Rao et al., 2015). Selecting the most suitable forages for the local system and conditions is critical. Smallholder and even larger-scale farmers depend heavily on advice from extension and development agencies, and from seed companies, but this advice is often limited by inexperience and the difficulty in accessing reliable information.

Selection of Forages for the Tropics (SoFT) is an open-access, online, expert knowledge system created by a team of renowned international forage specialists between 2000 and 2005. It is the preeminent source which provides detailed information on 180 major forages grown in the tropics and sub-tropics and incorporates a species selection tool based on target environment and forage use. The ability to select and prioritize forages for specific niches, environments, socio-economic conditions and specific animal requirements is important to mitigate feed shortages and improve natural resource management as part of sustainable farming systems.

Since its release in 2005, SoFT has been extensively used by researchers, extension agencies, NGOs, informed (livestock) farmers and educational institutions around the world, with an average of >250,000 website visits and >175,000 unique visitors per year. Although those numbers are impressive, research has advanced during the last 10-15 years and generated new information on forage performance and use in a wide range of environments. At the same time, rapid advances in knowledge management and information technology were made, such as the use of mobile devices and automatic translation features.

Updating the original SoFT tool to a new, improved version ("Tropical Forages" from here on), was proposed to ACIAR as SRA project in 2016 and funded from 2017-2019. The aim of this project was to enrich Tropical Forages both in terms of content and technical features, in order to enhance its quality, utility, usability and reach.

4 Project objectives and structure

The project had two specific objectives:

1. Updating and expanding the technical information on tropical forages (factsheets)
2. Enhancing access to and delivery of knowledge on tropical forages

The project was coordinated and implemented by CIAT as two integrated modular work packages, one on knowledge about forages and one on knowledge delivery. Together, these resulted in an updated online expert knowledge system and sharing tool, *Tropical Forages*.

Module 1: Updating and improving tropical forages knowledge

This module focused on the knowledge content of the tool, including factsheet revision, new factsheet preparation and improvements of the selection tool. Key activities included:

A) Factsheets

- Revision of the adequacy of the list of species in SoFT – determine additions, deletions and modifications
- Updating and editing existing factsheets and preparation of new factsheets on other important forage species that integrate published information on agronomy and management
- Improvement of all factsheets by proposing, where potentially relevant, core collections

B) Selection Tool

- Definition of weaknesses in current selection criteria used in the selection tool
- Incorporation of new species into the selection tool and testing it across a full range of environments and uses
- Verification and validation of the quality of the information provided in the tool

Module 2: Improving access to tropical forage information

This module focused on the ICT and knowledge-sharing component of the project. Key activities included:

- Updating the selection tool to new technology
- Incorporation of a feedback mechanism for users to comment on existing information or to add new information via editorial panel
- Development of a new website to provide rapid access to the data around the world
- Search engine optimization and automatic translation
- Development of a mobile application

Based on these two modules, the project produced the following deliverables:

- Updated content of the knowledge tool, incorporating advances in forage research over the last 15 years and in particular giving attention to eco-system service functions of forages
- An updated knowledge tool incorporating advances in ICT, i.e. usability across a range of platforms, improved search engines and a new feedback mechanism for future knowledge updates
- Availability of the knowledge tool through mobile devices enhancing accessibility in particular for the youth.

5 Methodology

The project required four different types of inputs:

- Factsheet analysis, updating and development
- Selection tool revision and updating
- Technical updates
- Product testing

The project was led by CIAT and its main mode of operation was sub-contracting to key consultants for the specific project inputs. These consultants worked mainly remotely. A total of two workshops were held, where both CIAT employees, the hired consultants and other forage experts came together to discuss advances and plan the way forward.

Workshop 1: October 2-6 2017 in Königstein, Germany. Main topics:

- Definition of the new name of SoFT (Tropical Forages)
- Factsheet format and content
- Taxonomy, images
- Selection criteria and environmental issues
- Technical updates: what is possible?
- Glossary and references
- Links to other sources, platforms and actors

Workshop 2: February 11-13 2019 in Königstein, Germany. Main topics:

- Presenting the prototype and new website design, and mobile application
- Identifying missing elements for the factsheets and selection tool
- Testing the selection tool
- Including a feedback option on the website
- Defining a communication strategy

Both workshop reports can be found in the Appendix.

A third and smaller workshop for final product testing was planned for the end of 2019/beginning of 2020 in Hainan, China. However, due to the COVID-19 outbreak, the location had to be changed to Brisbane, Australia. After the pandemic further evolved, the workshop was put on hold and will be carried out once the situation is clearer.

The release of the final product was planned for after the final product testing workshop. Since it is unclear when and in which form this workshop can happen, we will release the product once the crisis has slowed down in the media and more attention can be given to the release. As a consequence, we might release a version that will be subject to small final changes to be made after the final product testing workshop was held.

6 Updating and expanding the technical information of tropical forages

Before updating the technical information of the tool, the project team considered it necessary to discuss its name after the update. This was done during the first workshop in Königstein, Germany (October 2017), and the team decided to change the old name “Selection of Forages for the Tropics (SoFT)” to the shorter and more striking name “Tropical Forages”. We however will maintain the web domain www.tropicalforages.info which is well established and is appearing as a top hit on tropical forages when using search engines.

The first step for updating and expanding the technical information of tropical forages was to revise the old factsheets from SoFT in terms of adequacy, weaknesses and missing species. This was done during the first workshop in Königstein, Germany (October 2017) and served as a basis for all further project work. Likewise, the selection criteria of the selection tool were revised for adequacy and new criteria to be included in the updated tool.

A) Factsheet revision and development

A total of 172 species was identified to be included in Tropical Forages (compared to 180 species in SoFT). Based on that output, the hired consultants started working on developing the factsheets – the most demanding task of the project. This included on the one hand updating the existing factsheets in terms of new scientific developments, changes with taxonomy, listing new accessions and common names and developing more knowledge on practical tips (for sowing or maintaining). On the other hand, it also included the development of completely new factsheets for species that have not been in the original version of the tool. For all factsheets, the project team identified new pictures (e.g. of plants, seeds), sought for the required permits with the owners, and edited them so that they would fit the factsheet format. A total of >2,000 pictures were selected, labelled and edited.

The list of factsheets in the new Tropical Forages tool can be found here, in the prototype: https://apps.lucidcentral.org/tropical_forages/text/entities/index.htm

As can be observed, the factsheets can now be downloaded as pdf (see example factsheet in the Annex - *Acroceras macrum*). Each factsheet contains information on:

- The scientific name of the species
- Synonyms
- Family/tribe
- Common names
- Morphological description
- Distribution
- Uses/applications
- Ecology
- Agronomy
- Feeding value
- Production potential
- Genetics/breeding
- Seed production
- Herbicide effects
- Strengths
- Limitations
- Selected references
- Cultivars
- Promising accessions

Since the factsheets were updated with new scientific developments, also all references were updated and their respective links checked for functioning. Likewise, the project team developed a glossary in order to guide the user through the tool.

B) Revision and adjustment of the selection tool

The old selection tool was revised and the project team decided to maintain its principal design and functioning but also to remove some of its weaknesses and add new features to it.

First, during the first project workshop in Königstein, Germany (October 2017), all selection criteria were revised and evaluated for their adequacy and fitting into the tool, and new potential selection criteria were discussed for inclusion. This was above all about additional environmental criteria (e.g. soil conservation (soil fertility, soil erosion), biosafety (insect control), water conservation, GHG mitigation, amenity grasses, agroforestry systems). However, the project team realized that for many species, this information is still scarce what makes it difficult to define accurate and comparable selection criteria. The decision was not to amplify the selection criteria.

After the revision of the selection criteria and during the second project workshop in Königstein, Germany (February 2019), all new factsheets were added to the selection tool and scored for the respective criteria whereas irrelevant factsheets were deleted. Likewise, all scores for the other factsheets were revised and amended where necessary. This helped to reduce the number of potential errors and the overall weaknesses of the selection tool. Once that was done, a first testing phase was started with the workshop participants. For this, several potential but contrasting forage selection cases (e.g. for Colombia, Zimbabwe, Australia) were evaluated and the project team realized that another in-depth revision of all species for the different selection criteria was necessary to adjust the scoring feature by feature. The final testing of the selection tool was therefore postponed to the project end and it was intended to conduct a final product testing workshop planned for the end of 2019/beginning of 2020 in Hainan, China. However, due to the COVID-19 outbreak, the location had to be changed to Brisbane, Australia. After the pandemic further evolved, the workshop was put on hold and will be carried out once the situation is clearer. This last workshop will lead to a very precise selection tool and product.

The selection tool can be accessed here

(https://apps.lucidcentral.org/tropical_forages/identify/key.html) and now contains the following selection criteria:

- Intended forage use: e.g. long term pasture, cut & carry, standover forage
- Latitude x Altitude
- Rainfall (annual average)
- Soil texture: light, medium, heavy
- Soil fertility: low, medium, high
- Soil pH: strongly acidic, acidic, neutral, alkaline
- Soil drainage: well drained, moderately drained, poorly drained
- Level of soil salinity: low, medium, high
- Level of available soil Al/Mn: low, medium, high
- Family: grass, legume, other
- Life cycle: annual, perennial
- Defined dry season: Up to 6 months, greater than 6 months
- Inundation: <1 week, <1 month, >1 month
- Growth form: forb, sub-shrub, shrub, tree
- Stem habit: erect/semi-erect, prostrate/procumbent, climbing/twining, stoloniferous, rhizomatous
- Grazing pressure: light, regular, heavy
- Shade environment: moderate, dense
- Frost intensity: light, heavy

7 Enhancing access to and delivery of knowledge on tropical forages

The first task of this work package was to update the selection tool to new technology so that it would be compatible with all internet browsers (before it was working principally on Internet Explorer). This was done immediately after project start in 2017 for the old version of the tool and then also applied to the new version.

After that, the core project activities began. On the one hand, technical support was provided by the IT team for factsheet development and selection tool adjustments. For the factsheets, this included new technical features such as a pdf-download-function (which makes it easier to store, send and print factsheets), support with photo and text editing, and the updating of the factsheets with all new technical information provided by the scientists. For the selection tool, the IT team adjusted the selection criteria as suggested by the scientists and linked all new factsheets to the tool. It also provided some new technical features for the selection tool, such as a “why discarded” function that explains why a certain forage was discarded from the list of promising forages for a certain scenario, or a “differences” function that allows for comparing different forages selected by the tool. All forages that are selected and discarded by the tool have a direct link to the related factsheet.

On the other hand, the IT team worked on the development of a new website since the old website was outdated and new design features were required in order to draw more attention to the tool. The website design was done in close contact with the scientists. The new website, which is now available as prototype (<http://bit.ly/SoFT-Test>), also contains new technical features such as:

- Subheadings: Now available making navigation easier
- Automatic translation through Google for more than 30 languages: This will enhance accessibility of the tool since the original version was only available in English.
- Search engine optimization: This will increase the visibility of the tool in search engines
- Feedback mechanism for users: This is an essential element and will be available in the final version. It will help the involved scientists to interact with the users of the tool and to get data on its use
- Website search function: This was enabled and allows word search in the content of the website (e.g. factsheets). This search is available offline as well.
- Cross-links to other species: Now available in the factsheets and glossary
- Ranking in the selection tool: The most important options (with the highest ranking) will appear on top of the selection list
- New functions in the selection tool to help the user: a) “best” shows the selection criteria that differentiates the most; b) “prune” discards selection features if they become irrelevant, this is not enabled by default as some people want to select differently; c) “shortcuts” by choosing one of the mentioned features one comes down to only one species; d) “why discarded” that explains why a certain forage was discarded from the list of promising forages for a certain scenario; and e) “differences” that allows for comparing different forages selected by the tool.

The IT team also developed a mobile application for Android and Apple phones and the test version is already available (<https://tinyurl.com/rxjevle>). It contains the same information and features as the website. With the mobile application, we hope to increase accessibility and visibility of the Tropical Forages tool, i.e. in remote and rural areas, focusing on farmers, extensionists and youth.

During the project lifespan, we monitored the user statistics of the tool (see Figure 1 and 2). Figure 1 shows that the number of total visits and unique visitors declined in 2018 and 2019, which resulted from various technical drawbacks we challenged during the updating

process, including server problems, dependency on Java for running the selection tool, etc. However, a clear increase can be observed in the number of pages consulted during each year, with more than 1,400,000 pages in 2019 (almost doubling compared to 2018). This indicated that the content, which was constantly improved during 2018 and 2019, is more interesting to the users and thus consulted more. This is also shown in Figure 2 on a monthly basis.

Figure 1: User stats of SoFT/Tropical Forages, 2013-19

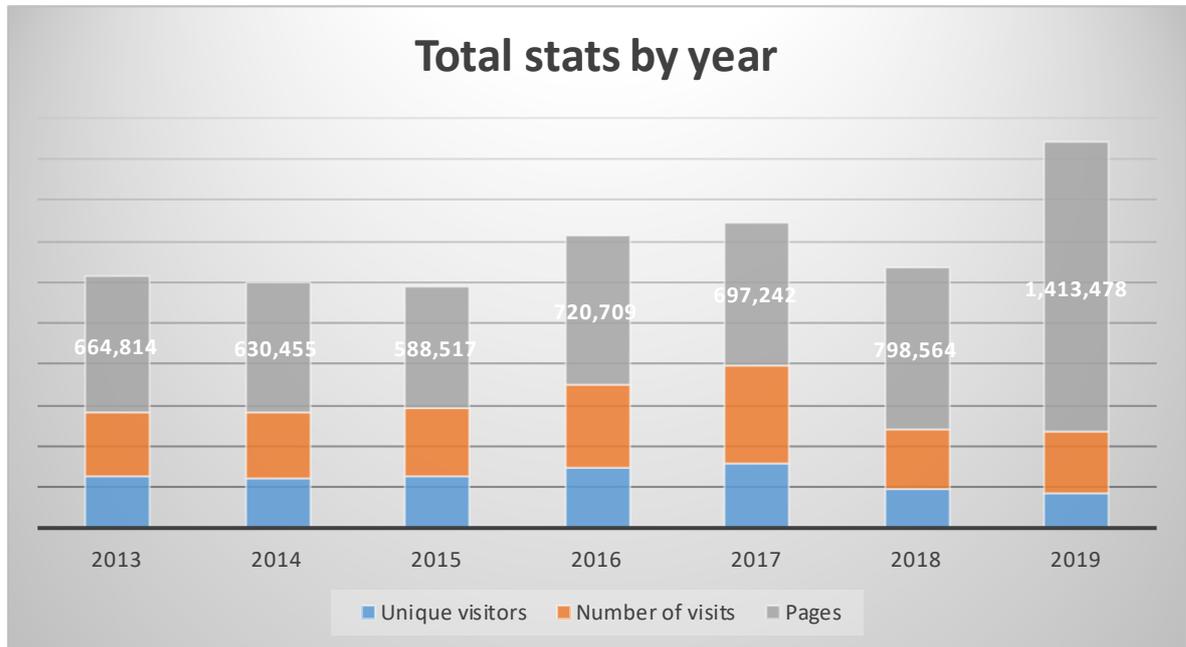


Figure 2: Number of pages visited/month of SoFT/Tropical Forages, 2013-19



After the final product is released, we are confident to reach significantly higher numbers of a) unique visitors, b) number of visits, and c) pages consulted. We believe to reach at least 500,000 users per year based on the following assumptions:

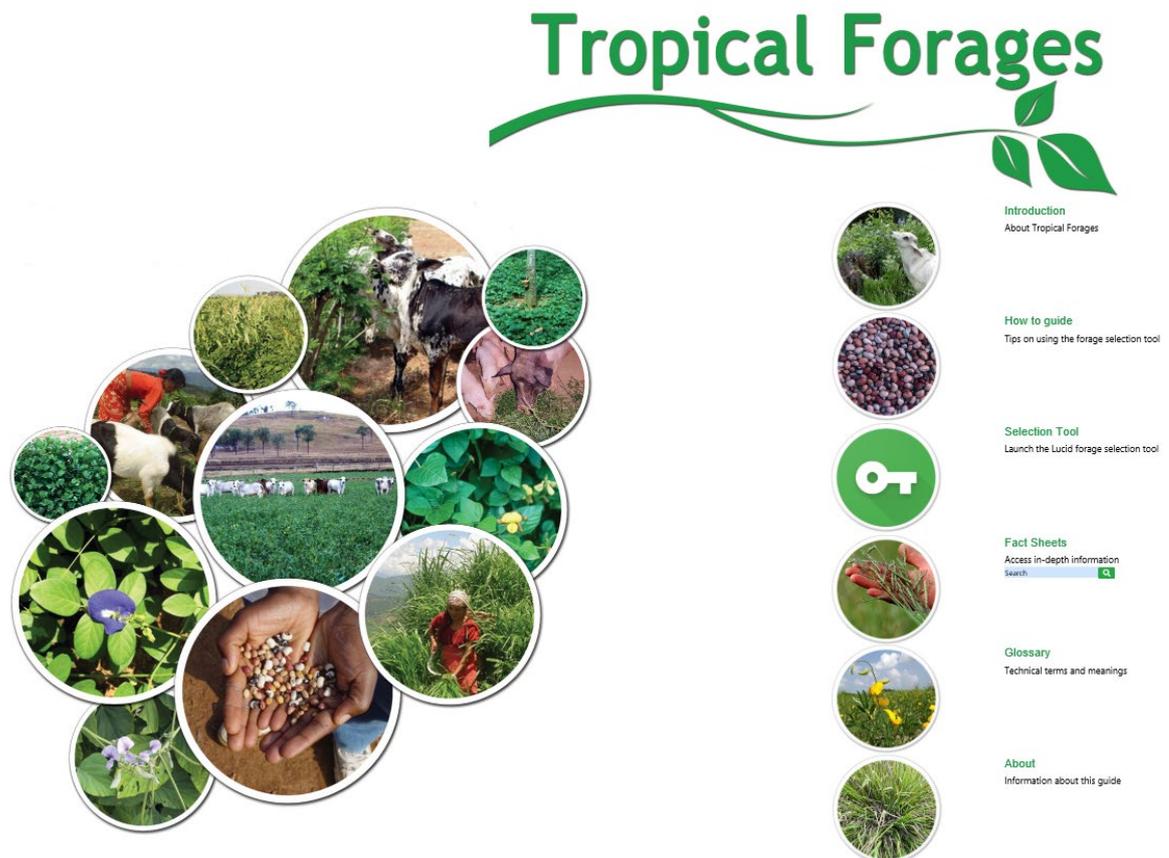
- The new tool is based on the most recent developments in terms of forages research and thus more interesting and relevant for our stakeholders
- The design and functionality of the website were improved and will attract more users

- The factsheet download option will make the tool more interesting for our stakeholders since they will be able to use the information offline
- The new mobile application will increase the reach of the tool and extend its use to rather remote rural areas, where internet is mostly available only on mobile phones
- The new mobile application will increase the interest of younger users
- New features in the selection tool and a better alignment of the tool will increase the users' interest in using it
- The automatic translation function will increase the reach of the tool and extend its use above all in countries where English is not the main language (e.g. Latin America and the Caribbean, Southeast and South Asia, parts of Africa)
- The search engine optimization will result in placing the tool among the first options when people search for tropical forages related issues. This will draw the attention of potential users

8 Tropical Forages – the prototype

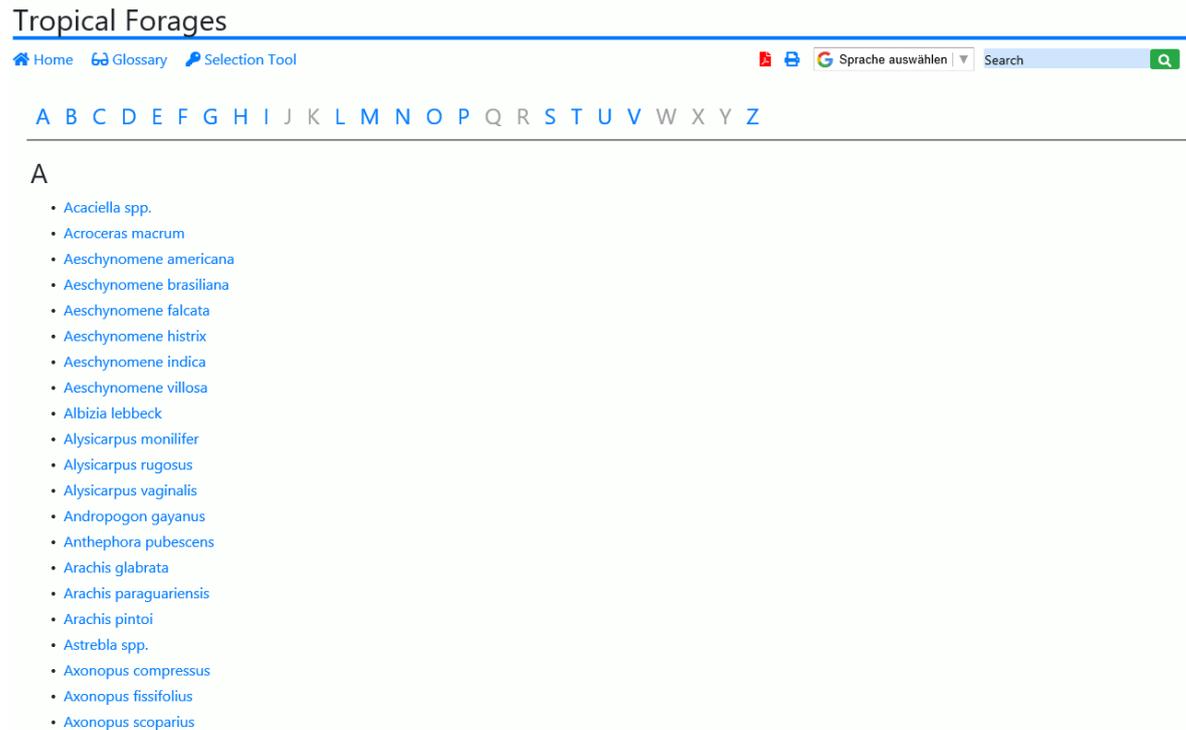
This section provides a short overview on the prototype of the new Tropical Forages tool. The prototype is available for the website (<http://bit.ly/SoFT-Test>) and mobile application (<https://tinyurl.com/rxjevle>).

Figure 3: The new homepage of Tropical Forages



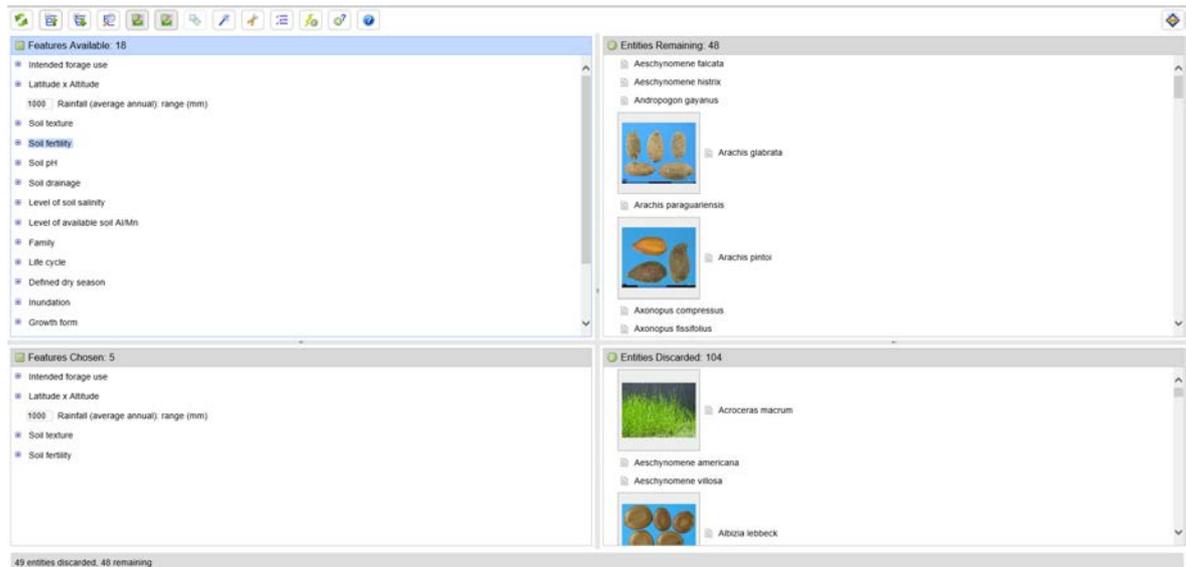
This screenshot gives a general idea on the tool's homepage design. Quick access is given to a short Introduction page, a How to guide page, the Selection Tool, the Fact Sheets, the Glossary and an About page.

Figure 4: The Factsheet page of Tropical Forages



The factsheet main page provides an alphabetical overview on all forage factsheets included in the tool. In the navigation line, shortcuts are provided to get to the homepage, the glossary and the selection tool. The pdf download and print buttons, the automatic translator and the search function are also available.

Figure 5: The Selection Tool of Tropical Forages



This image shows the selection tool with the available selection features (upper left box), the chosen features (lower left box), the remaining entities or chosen forages (upper right box) and the discarded forages (lower right box). The navigation list contains buttons for example for the “shortcut” or “why discarded” features described in chapter 7.

9 Product release, communication and dissemination

Product release:

The prototypes of the new Tropical Forages website (<http://bit.ly/SoFT-Test>) and mobile app (<https://tinyurl.com/rxjevle>) are already available and currently in the final testing phase. Due to the COVID-19 pandemic, the final testing meeting had to be postponed for now and a change of location was necessary (from China to Australia). The project team also decided to wait with the official release until the crisis has calmed down and adequate attention and media coverage can be given to the release.

Communication and dissemination strategy:

During the project lifespan, advances were already communicated to the wider public through e.g. blog posts or short notifications in two Forages for the Future Newsletters (see list of publications). CIAT, ILRI and the CGIAR Research Program on Livestock plan a strong campaign for accompanying the release of the final product, including blog posts, interviews, media coverage, among others. On a more continuous basis, CIAT and ILRI researchers will promote the tool through the innovation platforms and roundtables they participate in, the CIAT-ILRI genebank will alert their visitors to use the tool, and we plan to provide success stories from Tropical Forages users globally. In addition, the Tropical Grasslands – Forrajes Tropicales Online Journal (<http://www.tropicalgrasslands.info/>) could serve as platform for continuous promotion of the tool. The Joint International Grassland & International Rangeland Congress, postponed to 2021 due to COVID-19 will further raise attention.

After the release of the new tool, we expect to reach even more users than with version 1, in particular in regions where access to information is granted mostly via mobile phones and tablets, e.g., Sub-Saharan Africa, East Asia and Central America and the Caribbean. Through providing a mobile application, we also hope to attract more farmers, extension workers and in general, youth.

10 Outlook on the future

Updating and maintaining a tool like Tropical Forages is a challenging task and involves time and costs. The project team is well aware of that and already thought about possible strategies. CIAT and ILRI will seek funding for providing continuous technical support and updates of the website and mobile application, since this has to be done roughly once a year. Regarding updates on the content of the tool, we feel confident to have an up-to-date product that will last again around 10 years before a major update will be necessary. Such major update however, will only be possible with another project of this dimension. The involved CIAT and ILRI researchers whenever required will do any smaller content updates.

11 Conclusions and recommendations

Due to the COVID-19 crisis, the release of the final Tropical Forages tool could not be achieved as planned by the end of this project. However, the technical and content improvements were all completed and the product prototype is ready for final testing. We are confident that the final product release will still be in 2020.

11.1 Conclusions

Updating the original SoFT tool to a new, improved version (“Tropical Forages” from here on), was proposed to ACIAR as SRA project in 2016 and funded from 2017-2019. The aim of this project was to enrich Tropical Forages both in terms of content and technical features, in order to enhance its quality, utility, usability and reach. Through a series of workshops, meetings and literature review, this project consulted with a group of scientists who provided global leadership to tropical forage research and development for the last 30 to 40 years. In terms of updating and improving the website content, all forages species were revised regarding their adequacy and obsolete species were deleted/new ones added, leaving 172 species in the new tool. The respective species factsheets were updated in terms of scientific knowledge, photos and cultivar/accession information. Missing factsheets were developed and added. The selection tool was updated regarding its functioning and selection criteria and all new species were incorporated. In terms of technical updates for improving the access to tropical forage information, the website was optimized for tablets and smartphones. In addition, a mobile application was developed. The design of the website was renewed, and several new functions, such as a pdf-download function for all factsheets, automatic google-translation for 30+ languages, and a user feedback mechanism were added. The prototypes of the new Tropical Forages website (<http://bit.ly/SoFT-Test>) and mobile app (<https://tinyurl.com/rxjevle>) are already available and currently in the final testing phase. After the final product is released, we are confident to reach significantly higher numbers of a) unique visitors, b) number of visits, and c) pages consulted. We believe to reach at least 500,000 users per year.

11.2 Recommendations

Updating and maintaining a tool like Tropical Forages is a challenging task and involves time and costs. Regarding updates on the content of the tool, we feel confident to have an up-to-date product that will last again around 10 years before a major update will be necessary. Such major update however, will only be possible with another project of this dimension.

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12.2 List of publications produced by project

Cook, B.G., Schultze-Kraft, R., Pengelly, B.C., Taylor, M., Jones, C., Burkart, S. and Peters, M. 2019. Tropical Forages: an interactive selection tool. CIAT and ILRI. https://apps.lucidcentral.org/tropical_forages/text/intro/index.html

Cook, B.G., Schultze-Kraft, R., Pengelly, B.C., Taylor, M., Jones, C., Burkart, S. and Peters, M. 2019. Tropical Forages: an interactive selection tool. Mobile application. CIAT and ILRI.

https://play.google.com/store/apps/details?id=com.lucidcentral.mobile.tropical_forages

Burkart, S. 2019. Tropical Forages Database. In: Maass, B. and Pengelly, B.C. 2019. *Forages for the Future*. Issue 9 – August 2019, p.3

<http://tropicalgrasslands.info/index.php/tgft/pages/view/Newsletter9>

Pineda, S. 2019. The new version of Tropical Forages selection tool is almost done! Blog post by CIAT, February 21 2019. <https://blog.ciat.cgiar.org/the-new-version-of-tropical-forages-selection-tool-is-almost-done/>

Pengelly, B.C. and Cook, B.G. 2018. Updating the international database for tropical forage adaptation and use. In: Maass, B. and Pengelly, B.C. 2018. *Forages for the Future*. Issue 7 – June 2018, p.6

<http://tropicalgrasslands.info/index.php/tgft/pages/view/Newsletter7>

13 Appendixes

13.1 Appendix 1:

SoFT II - Workshop 1 - Meeting minutes

13.2 Appendix 2:

SoFT II - Workshop 2 - Meeting minutes