Design Requirements for Crop-Specific Online and Web-based Portals

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Abstract. Legumes such as common beans (*Phaseolus vulgaris L.*) continue playing a critical role in making developed and developing economies food sustainable as alternative sources to animal proteins. The crop bring together different stakeholders in its value chain such as farmers, service providers, researchers and policymakers. Web-based portals are emerging as important tools that these different stakeholders can use to perform various tasks, access, and share information pertaining to common beans. However, designing portals that are specific to common beans has not been given adequate consideration in the literature. In this study, we administered a survey to profile challenges and design requirements for web-based portals that are specific to common beans. We present the survey findings in this paper. The findings provide useful insights to researchers and industry in developing future agricultural web-based portals. The survey findings can be applied to portals on other crops or different domains.

Keywords: user requirements · user interface design · online portals · food security

1 Introduction

Sustainable access to information is vital in agricultural activities [2, 9]. Recently, web-based portals have received a lot of attention from research and industry as important sources of agricultural information such as information on pest control and management for common beans [3, 4, 10]. Common beans (*Phaseolus vulgaris L.*) is an important crop in developing regions since it serves as an alternative source to animal proteins. Subsequently, different stakeholders including those in agriculture, service providers, research, and policy making rely on the web-based portals to access and share valuable information that can help farmers in managing their crops well based on up-to-date crop management practices. However, from the literature, existing portals are not specific and particular to

common beans. As such, the existing agricultural portals are cluttered with a lot of information that can make it difficult for farmers to get important information on common beans at a glance. Additionally, designing portals that are specific to common beans has not received adequate attention in the literature. This can be a problem in developing regions where farmers operate in rural areas and accessing web-based portals in such areas is faced with various challenges such as internet access issues. Addressing this gap can help in advancing adoption of information and communication technologies in performing agricultural activities in both developed and developing regions.

In this study, we administered a survey to: (i) profile internet usage by stakeholders of common beans, (ii) document the challenges faced by stakeholders when accessing online information on legumes such as common beans, (iii) identify preferred services and features, (iv) identify preferred document formats and portal subscription modes, and (v) determine design requirements for crop-specific web-based portals. We used the survey findings to model design requirements as a function of different portal features. The overall findings can be used by researchers and industry when implementing agriculture related information portals.

Research Questions: The study was guided by the following research questions:

- **RQ1:** What are the challenges faced by stakeholders when accessing information online for common beans?
- **RQ2:** What are the preferred services and features on online portals for common beans?
- **RQ3:** What are the design requirements for portals focussing on common beans?
- **RQ4:** What are the features that can be used to attract users to visit portals for common beans?
- **RQ5:** What document formats are preferred by stakeholders on portals for common beans?
- **RQ6:** What subscription modes are preferred by stakeholders on portals for common beans?

Contributions: This study makes the following two contributions: (i) the study documents challenges faced by stakeholders when accessing online information on common beans, and design requirements for common beans online portals, and (ii) the study proposes a model for grouping design requirements for online portals on common beans. The model can be extended to other crops.

In the subsequent sections, we present and discuss materials and methods in Section 2, survey results in Section 3, preliminary prototype portal in Section 4, answering research questions in Section 5, related work in Section 6, and lastly, conclusions and directions for future work in Section 7.

2 Materials and Methods

An online questionnaire was circulated to different stakeholders for common beans portals: (i) farmers, (ii) researchers and policymakers, and (iii) service providers. The purpose of the questionnaire was to collect data that could help in answering the research questions described in Section 1. In order to identify the questionnaire items, we studied related research articles and related portals such as LegumePlus[3], Legume Information System[4], Grains & Legumes Nutrition Council[5], ILDIS World Database of Legumes[6] etc. From this study, we noted the type of users, common portal features and services. We used this knowledge to inform and design the items of our questionnaire. This process went through several iterations before being digitised into an online form. The questionnaires were applied between September 10 and October 19 2020 to respondents in Nairobi-Kenya, which is a developing region in East Africa. A total of 27 respondents were purposively selected (9 farmers, 13 researchers and policymakers, and 5 service providers) based on their participation in agricultural research and technology transfer projects in one of the leading agricultural university in the region and government agencies. The questionnaire items were grouped according to the research questions. The questions were both closed-ended and open-ended to solicit more feedback from the respondents. An ordinal scale (such as "not important, slightly important, important, very important") was used on the questionnaire items to guide the responses received. The online questionnaires were sent to the email addresses of the target respondent. Weekly email reminders were sent to the unresponsive respondents to motivate them to fill in the survey. The data collected was analysed and the results are presented in this paper.

3 Results and Discussion

In this section, we present and discuss the findings of this study as follows:

- Demographic information,
- Access to internet and usage,
- Stakeholder knowledge on existing portals form common beans,
- Challenges faced when accessing online information on common beans,
- Preferred services and features on online portals for common beans,
- Design requirements,
- Styles for designing portals for common beans and placement of menus,
- Methods and features that can be used to attract users to portals for common beans,
- Preferred document formats, and
- Preferred portal subscription modes.

[3] http://legumeplus.eu
[4] https://legumeinfo.org
[5] https://www.glnc.org.au
[6] https://www.ildis.org

3.1 Demographics

This section shows the distribution of survey respondents in terms of gender, academic qualifications, crops focused on, access to the internet, means of accessing the internet, and years of internet usage.

Gender and Academic Level Distribution: Table 1 shows the gender distribution for the survey respondents. Generally, there were more male survey respondents compared to female respondents. In this study, we do not focus on any specific gender. Table 2 shows the academic distribution of the survey respondents. On average, there were more respondents with postgraduate academic qualifications. This was important to reduce errors that could arise when providing responses to the survey questions.

Table 1: Gender distribution of survey respondents.

Gender	**Farmers**	**Researchers and policymakers**	**Service providers**	**Average**
Male	88.9%	69%	80%	79.3%
Female	11.1%	31%	20%	20.7%

Table 2: Academic level distribution of survey respondents.

	Diploma	**Undergraduate degree**	**Masters degree**	**Doctorate degree**
Farmers	11.1%	22.2%	11.1%	55.6%
Researchers and policymakers	0.0%	0.0%	23.0%	77.0%
Service providers	0.0%	0.0%	60.0%	40.0%
Average	3.7%	7.4%	31.4%	57.5%

Focus Crops and Role Played: Most farmers grow peas, lentils, cowpeas, and beans; fewer farmers grow soybeans. The farmers played different roles in the farm with 44.4% being farm owners, 11.1% as chief farm managers, 22.2% as agricultural instructors, 11.1% as farm supervisors, 11.1% as consultants, and another 11.1% as research assistants. Majority of the service providers handled desmodium followed by beans. 20% of the service providers handled beans and another 20% handled chickpeas. For researchers and policymakers, the main fields of professional engagement were agriculture at 30.8%, food nutrition, food science and technology, social science and humanities (all at 15.4% each), and computing and information technology at 7.6%.

Access to the Internet: As shown in Table 4, 96.3% of the respondents had access to the internet. This is an important statistics that emphasises the need for online portals with information on particular crops. As mentioned before, such portals can make information access and sharing among users easy.

Table 3: Access to the internet.

	Farmers	**Researchers and policymakers**	**Service providers**	**Average**
Yes	88.9%	100%	100%	96.3%
No	11.1%	0%	0%	3.7%

Means of Accessing the Internet: The means of accessing the internet were grouped into four main categories as shown in Table 4. On average, most of the stakeholders accessed the internet from their mobile phones or tablets using either cellular or WiFi connections. With the increased adoption of smartphones in developing regions, we anticipated to get this kind of results for an urban area setting. Accessing the internet directly from mobile phones or tablets is more flexible especially to farmers that spent most of their time in farm fields. This reduces on time and effort to visit internet cafes, and hence the low response on internet cafes as a means of accessing the internet.

Table 4: Means of accessing the internet.

Category	**Farmers**	**Researchers and policymakers**	**Service providers**	**Average**
Internet access directly from mobile phone or tablet	75.0%	69.2%	80%	74.7%
WiFi connectivity at the place of residence or work	37.5%	84.6%	80%	67.4%
Wired connectivity/LAN at the place of residence or work	37.5%	53.8%	60%	50.4%
Internet cafe	12.5%	0.0%	0.0%	4.2%

Years of Internet Usage: From Table 5, most of the respondents have used the internet for more than 10 years. This tallies with the academic levels where most respondents were doctorate degree holders that encompasses a huge component of research. In modern times, the internet is a big source of research materials and information. Also, the spread of smartphones started experiencing peaks about a decade ago and changed access to information within much of the developing world [1]. As such, with smartphones, internet access was brought closer to the end-user.

Table 5: Years of internet usage.

	Farmers	**Researchers and policymakers**	**Service providers**	**Average**
$<$ 1 year	0.0%	0.0%	0.0%	0.0%
1 – 5 years	25.0%	23.1%	0.0%	16.0%
6 – 10 years	50.0%	0.0%	0.0%	16.7%
$>$ 10 years	25.0%	76.9%	100.0%	67.3%

3.2 Knowledge on Existing Legume Portals

Table 6 shows the knowledge the respondents had on existing legume portals. Most respondents had knowledge on IFPRI[7] portal. This portal has a food price watch section which is useful to most of the respondents. However, the average percentage of respondents with knowledge on existing portals was less than 40%. This is despite the fact that most respondents had access to the internet. We believe, this situation is occasioned by the information on existing legume portals not being entirely focused on common beans. As such, we think that some users did not spend enough time on those portals to get the kind of information they were expecting or looking for on those portals. From a user experience perspective, failing to get the expected information at the first visit to the portal can be a barrier to non-returning portal users.

Table 6: Knowledge on existing online legume portals.

	Farmers	**Researchers and policymakers**	**Service providers**	**Average**
http://legumeplus.eu	11.1%	7.7%	0.0%	6.3%
https://www.glnc.org.au/	33.3%	23.1%	0.0%	18.8%
https://www.ildis.org/	11.1%	0.0%	0.0%	3.7%
https://legumeinfo.org/	11.1%	0.0%	0.0%	3.7%
http://www.legato-fp7.eu/	0.0%	0.0%	0.0%	0.0%
http://tropicallegumes.icrisat.org/	11.1%	15.4%	0.0%	8.8%
https://www.foodsecurityportal.org/	33.3%	61.5%	20.0%	38.3%

3.3 Challenges Faced

Table 7 shows the challenges cited when accessing legume resources online. Lack of portals on common beans was the most cited challenge followed by irrelevant portal content. This resonates with the findings in Section 3.2. We believe that this is because the existing portal are generic to agriculture and not specific to common beans. On irrelevant portal content, we believe that this challenge is occasioned by cluttering of information on existing portals that can make it difficult to get relevant information at a glance.

[7] https://www.foodsecurityportal.org/

Table 7: Challenges faced when accessing legume portals.

Challenges	Farmers	Researchers and policymakers	Service providers	Average
Lack of internet	11.1%	0.0%	0.0%	3.7%
Slow internet	11.1%	23.1%	20%	18.1%
Lack of portals on common beans	66.7%	23.1%	80%	56.6%
Irrelevant portal content	22.2%	15.2%	40%	25.8%
Online privacy and trust concerns	11.1%	7.7%	20%	12.9%

3.4 Services and Features

Table 8 presents services and features considered important by different stakeholders if they were made available on portals for common beans from the most to the least important. The ratings based on the responses received are as illustrated in Figure 1(a), Figure 1(b), and Figure 1(c). In general, stakeholders consider information on food composition, human nutrition requirements, weather information, and documentary series (with information on seed systems, processing and marketing, breeding, and crop management) as important to have on portals for common beans.

Table 8: Preferred services and features from most to least important.

Researchers and policymakers	Farmers	Service providers
(a) Information on common bean food composition and recipes. (b) Documentary series e.g., on seeds. (c) Common bean projects and publications. (d) Common bean research opportunities e.g., research grants. (e) Functionality for policy analysis tools e.g., dietary guidelines. (f) Functionality for news and events. (g) Policy reports and key documents. (h) Nutritional journals e.g., with information on food consumption. (i) Weather information and common bean crop calendars. (j) E-learning courses and workshops. (k) Media and advocacy. (l) Post harvest management. (m) Dashboards to visualise relevant. (n) Online social media features e.g., newsfeeds and webinar recordings. (o) Bulletins.	(a) Markets, prices and interactions. (b) Information on common bean food composition and recipes. (c) Documentary series e.g., on seeds. (d) Request for services e.g., labour and extension services. (e) Nutritional journals e.g., with information on food consumption. (f) Weather information and common bean crop calendars. (g) Functionality for news and events. (h) E-learning courses and workshops. (i) Policy reports and key documents. (j) Online social media features. (k) Functionality for policy analysis tools e.g., dietary guidelines. (l) Media and advocacy.	(a) Weather information and common bean crop calendars. (b) Functionality for policy analysis tools e.g., dietary guidelines. (c) Funding opportunities and support. (d) Online resources for local markets within Kenya. (e) Markets, prices and interactions. (f) Information on common bean food composition and recipes. (g) Policy reports and key documents. (h) Online social media features. (i) Functionality for news and events. (j) Media and advocacy.

3.5 Design Requirements

Table 9 shows the design requirements for common beans portals from the most to the least important. The ratings for these requirements are shown in Figure 2(a), Figure 2(b), and Figure 2(c). In general, portals for common beans should be easy to navigate and access (or locate and get) items of interest (e.g.,

(a) (b) (c)

Fig. 1: Services and features deemed important by (a) researchers and policymakers, (b) farmers, and (c) service providers. The letters on the horizontal axes correspond to the respective services and features as indicated in Table 8.

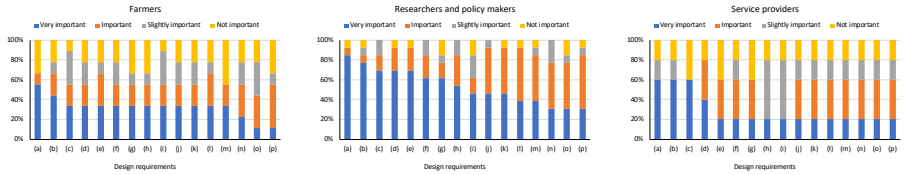
Table 9: Design requirements from most to least important.

Researchers and policymakers	**Farmers**	**Service providers**
(a) Easy to navigate and access e.g., documents, and menu items. (b) Protects user's privacy. (c) Easy to reverse or cancel actions. (d) Easy to understand and use i.e., intuitive and simple. (e) Responds to user's instructions by providing appropriate feedback. (f) Efficient i.e., the portal is fast. (g) Keeps users informed about its current state e.g., highlighting the active menu. (h) Offers mechanisms for error prevention e.g., input validation. (i) Personalised to specific needs or profile of user. (j) Enables users recognise, diagnose, and recover from errors. (k) Provides all the services the user wants. (l) Consistency e.g., in design layout. m) Provides help facilities. (n) Provides multiple ways of doing things. (o) Visually appealing e.g., in layout. (p) Familiarity and metaphors e.g., uses images the user is familiar with.	(a) Easy to understand and use i.e., intuitive and simple. (b) Easy to navigate and access e.g., documents, and menu items. (c) Consistency e.g., in design layout. (d) Personalised to specific needs or profile of user. (e) Provides multiple ways of doing things. (f) Efficient i.e., the portal is fast. (g) Easy to reverse or cancel actions. (h) Provides help facilities. (i) Visually appealing e.g., in layout. (j) Keeps users informed about its current state e.g., highlighting the active menu. (k) Responds to user's instructions by providing appropriate feedback. (l) Familiarity and metaphors e.g., uses images the user is familiar with. m) Protects user's privacy. (n) Enables users recognise, diagnose, and recover from errors when they occur. (o) Offers mechanisms for error prevention e.g., input validation. (p) Provides all the services the user wants.	(a) Provides multiple ways of doing things. (b) Efficient i.e., the portal is fast. (c) Easy to navigate and access e.g., documents and menu items. (d) Easy to reverse or cancel actions. (e) Consistency e.g., in design layout. (f) Personalised to specific needs or profile of user. (g) Offers mechanisms for error prevention e.g., input validation. (h) Enables users recognise, diagnose, and recover from errors when they occur. (i) Provides help facilities. (j) Visually appealing e.g., in layout. (k) Easy to understand and use i.e., intuitive and simple. (l) Provides all the services the user wants. m) Keeps users informed about its current state e.g., highlighting the active menu. (n) Responds to user's instructions by providing appropriate feedback. (o) Familiarity and metaphors e.g., uses images that the user is familiar with. (p) Protects user's privacy.

documents, menu items, links of interest), efficient (i.e., the portal is fast). In addition, for researchers and policymakers, the portal should be able to respond to end-user instructions through appropriate feedback mechanisms, protect end-user's privacy, be easy to reverse or cancel actions, and also be easy to understand and use. For farmers, the portal should be easy to understand and use, be personalised to specific needs, be consistent in design and layout, provide multiple ways of doing things, and be efficient (i.e., fast). For service providers, in addition to the above, the portal should provide mechanisms for error prevention, provide help facilities, and be visually appealing.

3.6 Portal Style and Placement of Menus

Farmers prefer portals with horizontal or vertical text, sub-menus and dropdown menus (Table 10). Service providers prefer portal that use icons or graphics, while researchers and policymakers prefer portals with horizontal text, sub-menus with icons or graphics.



(a) (b) (c)

Fig. 2: Design requirements as rated by (a) farmers, (b) researchers and policymakers, and (c) service providers from the most to the least important as indicated in Table 9.

In terms of placing major links or menus, service providers prefer links/menus on the right, while researchers and policymakers prefer links/menus either on top or left (Table 11). Lastly, farmers prefer links/menus on top, right or left side of the portal. On average, most respondents prefer right menus followed by top menus.

Table 10: Portal style and placement of menus.

	Horizontal text	**Submenus**	**Vertical text**	**Drop down menus**	**Icons or graphics**
Researchers and policymakers	31%	23%	15%	8%	23%
Farmers	33%	0%	33%	22%	11%
Service providers	0%	0%	20%	20%	60%
Average	21.3%	7.7%	22.7%	16.7%	31.3%

Table 11: Portal style and placement of menus.

	Left menu	**Right menu**	**Top menu**	**Bottom menu**
Researchers and policymakers	38%	0%	54%	8%
Farmers	22%	33%	33%	11%
Service providers	0%	100%	0%	0%
Average	20.0%	44.3%	29.0%	6.3%

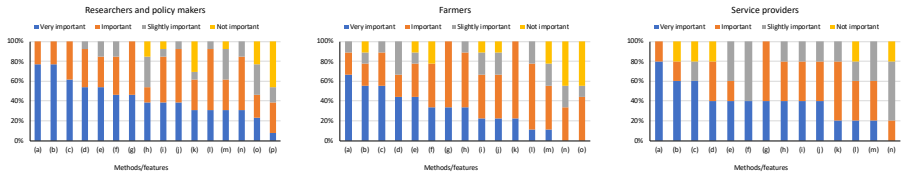
3.7 Portal Attraction Methods and Features

Table 12 shows different methods and features that can attract users to portals for common beans from the most to the least important. The results of the ratings are as indicated in Figure 3(a), Figure 3(b), and Figure 3(c). Researchers

and policymakers consider updated portal content, efficient and effective customer support, supporting users to reset or remember forgotten usernames and passwords as key attracting methods/features to portals for common beans (Figure 3(a)). Farmers consider support for use of modern farming techniques, supporting users to reset or remember forgotten usernames and passwords, and updated portal content as key attracting methods/features to portals for common beans (Figure 3(b)). Lastly, service providers consider personalising portal features, rewarding royal customers, special offers and gifts (e.g., free content downloads) as key attracting methods and features to common bean portals (Figure 3(c)).

Table 12: User attraction methods and features

Researchers and policymakers	**Farmers**	**Service providers**
(a) Keeping the portal's content updated. (b) Efficient and effective customer support. (c) Supporting users reset or remember forgotten usernames and passwords. (d) Providing online suggestions and feedback. (e) Supporting online discussion forums. (f) Supporting users to create their user profile. (g) Support for use of modern farming techniques. (h) Rewarding loyal users. (i) Special offers and gifts e.g., free downloads. (j) Providing users with online newsfeeds. (k) Online adverts (on the portal). (l) Email alerts and reminders. m) Personalising portal's features and services to user profiles. (n) Supporting blogging. (o) Enabling users to make and find friends online. (p) Offline advertising.	(a) Support for use of modern farming techniques. (b) Supporting users reset or remember forgotten usernames and passwords. (c) Keeping the portal's content updated. (d) Rewarding loyal users. (e) Special offers and gifts e.g., free downloads. (f) Providing online suggestions and feedback. (g) Supporting users to create their user profile. (h) Providing users with online newsfeeds. (i) Email alerts and reminders. (j) Personalising portal's features and services to user profiles. (k) Supporting online discussion forums. (l) Supporting blogging. m) Enabling users to make and find friends online. (n) Online adverts (on the portal). (o) Offline advertising.	(a) Personalising portal's features and services to user profiles. (b) Rewarding loyal users. (c) Special offers and gifts e.g., free downloads. (d) Online adverts (on the portal). (e) Email alerts and reminders. (f) Supporting users reset or remember forgotten usernames and passwords. (g) Keeping the portal's content updated. (h) Supporting online discussion forums. (i) Supporting blogging. (j) Supporting users to create their user profile. (k) Providing online suggestions and feedback. (l) Enabling users to make and find friends online. m) Providing users with online newsfeeds. (n) Offline advertising.



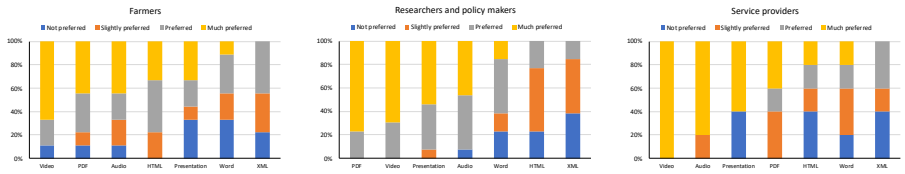
(a) (b) (c)

Fig. 3: Methods/features that can attract (a) researchers and policymakers, (b) farmers, and (c) service providers to a common bean portal from the most to the least important as indicated in Table 12.

3.8 Preferred Portal Document Format(s)

Figure 4(a), Figure 4(b), and Figure 4(c) show the preferred document format in order of the preferred priority. Farmers prefer video content followed by portable

document format (PDF) content (Figure 4(a)). Researchers and policymakers prefer PDF followed by video content (Figure 4(b)). Lastly, service providers prefer video content followed by audio content (Figure 4(c)). Video content is preferred since it can provide demonstrations with audio explanations that users can easily follow. Farmers do not prefer word or presentation document formats. This can be attributed to the fact that these document formats may require computing devices with large screens for display; accessing these devices in a farm setting can be challenging. XML and HTML document formats are not preferred because they require translation into a form that can be understood. Such translation requires experiences in computer programming which can be difficult to non-programmers.



(a) (b) (c)

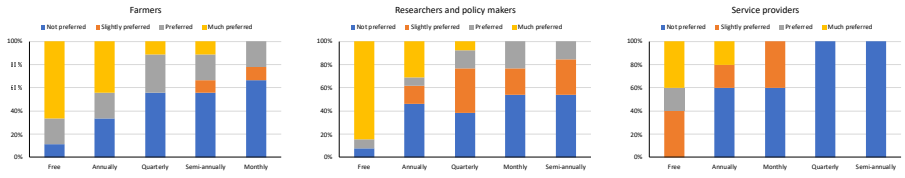
Fig. 4: Preferred document format by (a) farmers, (b) researchers and policymakers, and (c) service providers.

3.9 Preferred Portal Subscription Mode(s)

Figure 5(a), Figure 5(b), and Figure 5(c) show the preferred portal subscription modes for farmers, researchers and policymakers, and service providers from the most to the least preferred. Most respondents prefer free content access on portals for common beans. A small fraction of the respondents agrees to monthly, semi-annual, and annual subscriptions. This can be as a result of the perceived costs that are associated with subscribing for premium content. Some content like video and audio can have a cost implication to prepare. Having such content on common bean portals may require a sustainable financial model. Portal designers and owners can consider a mix (hybrid) of both free and premium content.

3.10 Study Bias and Limitations

Open questions such as “Other: ..." were included in the online questionnaire to collect new requirements. The data collection questionnaire was circulated on email. As such, this implied that only respondents with internet access could respond to the questionnaire. Moreover, with online questionnaire, it was difficult to ascertain the sample providing the information was the right person.



(a) (b) (c)

Fig. 5: Subscription mode by (a) farmers, (b) researchers and policymakers, and (c) service providers in order of preference.

Nonetheless, the received information provides useful insights to the implementation of portals for common beans. The insights drawn can be extended to the design of other portals.

4 Model and Prototype Design

From the analysis of the survey responses, we propose the model illustrated in Equation (1) for portal design requirements. We base the proposed model on: (i) preferred portal features, (ii) preferred document formats, (iii) portal style and placement of links, and (iv) non-core features like subscription modes for content.

$$D_r = \Gamma + \Upsilon + \Phi + K \tag{1}$$

where,
D_r refers to the portal design requirements,
Γ is the set of preferred features,
Υ is the set of preferred document formats,
Φ is the set of preferred portal style and placement of links, and
K is the set of additional portal elements like subscription mode for content.

For crop specific portals, the elements in the model will often remain similar since the same stakeholders apply. For portals in other domains, the model elements can change since the stakeholders can be different.

4.1 Model Usage

To validate the model proposed in Equation (1), we grouped the identified requirements from the survey results as follows;

$\Gamma = \{\gamma_1, \gamma_2, \gamma_3\}$: γ_1 = section for news and events for dynamically updated content, γ_2 = media and advocacy section, γ_3 = stakeholder specific sections.

$\Phi = \{\phi_1, \phi_2, \phi_3\}$: ϕ_1 = horizontal text, ϕ_2 = drop down menus, ϕ_3 = use of images.

$\Upsilon = \{\upsilon_1, \upsilon_2\}$: υ_1 = section for free resources, υ_2 = section for free datasets. The free resources can motivate users to visit the portals since it was the most preferred subscription mode.

$K = \{\kappa_1, \kappa_2, \kappa_3\}$: κ_1 = responsive design to foster accessibility from different devices, κ_2 = consistent layout, κ_3 = links to social media and blogging platforms to keep users updated.

The above grouping, yielded a set of design requirement that we used to generate the prototype described in Section 4.2. This model can be used to identify, classify, and group requirements for portals in other domains or for other crops.

4.2 Portal Architecture

Figure 6 shows the overall prototype architecture. This architecture portrays three key portal actors: users, content providers, and the portal administrator(s). The administrator performs administrative tasks such updating menu items or adjusting the portal design layout. The content providers gives useful information that is relevant to the different portal stakeholders. Lastly, the users (farmers, service providers, researchers and policymakers) access the portal to consume the information provided.

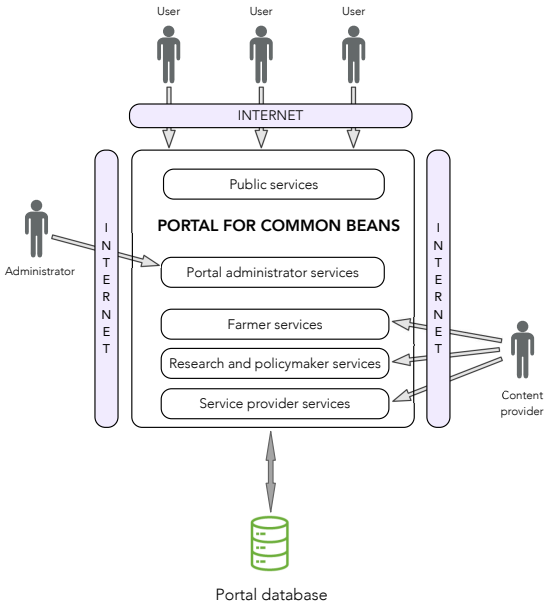


Fig. 6: Overall architecture of the prototype web portal.

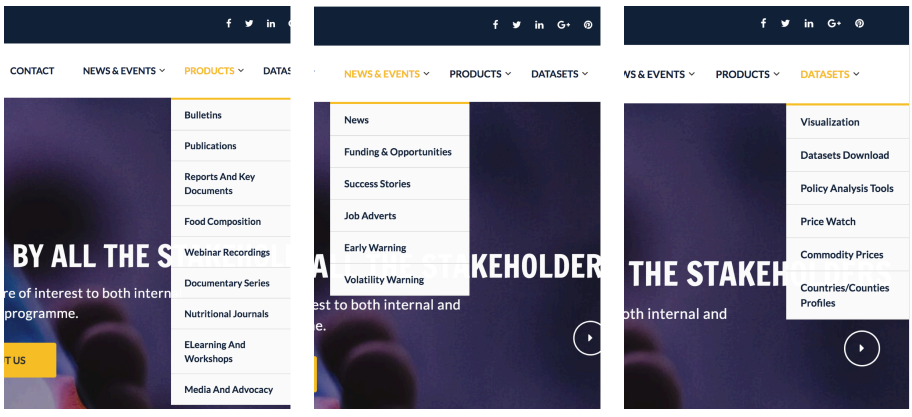
4.3 Design Decisions

We based our prototype on the following design decisions:

- *Text alignment:* From the survey findings, farmers, researchers and policymakers prefer horizontal text. All the stakeholders prefer vertical text alignment. In our prototype design, we employ a mixture of the two approaches.
- *Menu type:* From the survey findings, farmers, service providers, researchers and policymakers prefer drop-down menus, while only farmers prefer submenus. Similarly, all the stakeholders prefer infographics such as icons and images. In our design, we selectively use icons and images that are relevant to the target crop.
- *Menu placement:* From the survey findings, farmers, researchers and policymakers prefer left, top, and bottom menus, while service provides prefer right menus. As such, in our prototype design, we utilised a mix of different menu placements. Moreover, most of the existing portals have top menus that are based on the top-down techniques of reading web pages.

We believe that the above design decisions can apply to portals on other crops or different domains.

The resulting prototype is as illustrated in Figure 7(a), Figure 7(b), and Figure 7(c). Figure 7(a) shows the portal attraction features such as food composition, bulletins, publications, nutritional journals etc. Figure 7(b) shows the drop-down menus that were preferred by most survey respondents. Figure 7(c) shows some of the resources that will be availed on the portal such as datasets, policy analysis tools, price watch, and visualisation tools. These features and resources can be replicated in portals that focus on different crops or domains.



(a) (b) (c)

Fig. 7: (a) Portal attraction features, (b) Drop down menus, and (c) Some datasets to be availed to stakeholders on the portal.

4.4 Comparison to Other Portals

Table 13 shows how the prototype portal compares to other agricultural portals. Most of the existing portals that we considered in this study use: (i) top menus with horizontal text alignment, (ii) drop down menus, (iii) icons or graphics. The prototype conforms to what other portals support i.e., making use of icons or graphics, drop down menus, and horizontal text alignment. To improve navigation through the legume portal, we employed a mix of different menu placement styles. As such, we have consistent top and bottom menus, while we use right and left menus on specific portal pages such as the pages for news and events.

Table 13: Comparing the preliminary prototype to other portals.

	Text alignment	**Menu type**	**Menu placement**	**Icons and graphics**
https://www.glnc.org.au/	HT	DDM	TM	✓
https://www.ildis.org/	HT	–	TM	✓
https://legumeinfo.org/	HT	DDM	TM	✓
http://www.legato-fp7.eu/	HT	–	LM, RM	✓
http://tropicallegumes.icrisat.org/	HT	DDM	TM, BM	✓
https://www.foodsecurityportal.org/	HT	–	TM, BM	✓
Our prototype	HT	DDM	TM, BM, LM, RM	✓

HT:- Horizontal text; DDM:- drop-down menus; IG:- LM:- left menus; RM:- right menus; TM:- top menus; BM:- bottom menus

5 Answering the Research Questions

This study was based on six research questions as described in Section 1.

RQ1: Challenges Faced: Broadband and cellular network access are now available in most developing regions. However, in these regions the internet connection speeds can be slow due to poor quality in some areas that are far away from urban centres. Often, this phenomenon can lead to intermittent network connections. The challenges associated with internet access can lead to a perceived lack of portals on common beans since accessing them becomes a problem. Moreover, from the literature, existing portals are general and not specific to particular crops. As such, their content can be perceived as irrelevant, and hence the need for methods and features to attract users to legume portals. We believe that stakeholders would visit crop specific online portals since the are tailored to provide specific crop information. Lastly, some of the existing agricultural portals require subscription for premium content that users can perceive to be costly.

RQ2: Preferred Services and Features: Farmers prefer portals that provide information on market prices, food composition, recipes, and documentary series on agricultural information. Additionally, they require portals that can allow them to request for services such as extension services. Researchers prefer portals that provide information on food composition, documentary series e.g., on seed systems, research opportunities such as project grants, and functionalities for policy analysis. Additionally, they require functionalities on news and events, and policy documents. Service providers prefer portals with weather information and crop calendars. This is important to schedule market campaigns or inform farmers about market conditions. Farmers can use such information to plan for crop harvesting, processing, and storage.

RQ3: Design Requirements: Online portals for common beans should be consistent in design in terms of portal layouts and use of colours. The content they provide should be personalised to user needs. In recent times, there is a growing concern for privacy and confidentiality. Portal designers should reassure users that the information they provide will not be used outside the intended purpose. The portals should also be efficient and easy to reverse or cancel actions. The above requirements can also apply to portals in other domains.

RQ4: Portal Attraction Methods and Features: Portals that address user specific needs are more attractive to that group of users. For instance, portals that address modern farming issues would attract farmers. From the portal administrative perspective, effective customer support (e.g., using chatbots) and rewarding royal users with incentives such as discounts on premium content can attract more users. Also, consistent email reminders on new information or content updates with pointers where to find it on the portal can attract users. Updated portal content makes the portal "fresh" from the perspective of the user.

RQ5: Preferred Document Formats: From the survey findings, video and audio content are most preferred because they can easily be accessed via smartphones. In addition, PDF and presentation documents are preferred. These documents can easily be accessed using smartphones and tablets as well. Though not preferred by the survey respondent, XML documents can be useful to portal designers especially when providing frequently changing portal content such as newsfeeds.

RQ6: Preferred Portal Subscription Modes: Portal subscription by users can be done monthly, quarterly, semi-annually, annually or portal content can be provided for free. Free subscription mode is preferred because of the associated costs on premium content. As mentioned before, having free content on legume portals may require a sustainable financial model. As such, we recommend portal designers and owners to consider a mix (hybrid) of both free and premium content.

6 Related Work

Several studies in the literature have documented research on online agricultural portals. Thanopoulos *et al.* [8] document an online web portal for training users in organic agriculture. The portal is used to organise, classify and publish digital informative, educational, and scholarly resources for organic farmers. Masner *et al.* [7] describe Agris which is a unified online information space for agriculture, food industry, forestry, water supply and distribution in rural areas. Jothi and Neelamalar [2] document the impact of portals in communicating agricultural information to farmers. The study focuses on analysing communication necessity via the internet to farmers in underdeveloped regions. Though not directly linked to portals, the study elaborates the importance of using the internet in rural communication especially to farmers. Marimuthu *et al.* [6] discuss about a persuasive technology method developed to help farmers adopt technology supported farming. The developed technology has a portal component to share information on marketing and farming accessories like dairy, organic products, and farm machineries. Walisadeera *et al.* [9] investigate how to create a knowledge repository for agricultural information while taking into account the context in which the information is needed. Lastly, Li *et al.* [5] analyse the feasibility and necessity of a public platform that can be used in agricultural information services. A micro website was established to realise the information transition from a PC website to the mobile web site.

7 Conclusion and Future Work

In this study, we profile challenges stakeholders face when accessing legume information online. These challenges can hinder adoption of ICTs in farming. As such, we document design requirements for online legume portals. We use the identified requirements to prototype a crop-specific legume portal. In the future, the preliminary prototype will be subjected to heuristic evaluation. The evaluation results will be used to inform subsequent refinements to realise an improved version that will be subjected to a user-based evaluation. The user-based evaluation will assess the design and placement of menus, and also assess the effectiveness of the methods/features used to attract users to the portal. Lastly, online portals compliment mobile applications in information dissemination. As such, future efforts will be channeled towards developing a mobile application that can be used with the refined online portal for common beans.

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