Society-Oriented Applications Development: Investigating Users' Values from Bangladeshi Agriculture Mobile Applications

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ABSTRACT

Limited consideration of users' values in mobile applications (apps) can lead to user disappointments and negative socio-economic consequences. Therefore, it is important to consider values in app development to avoid such adverse effects and to secure the optimum use of apps. With this aim, we conducted a case study to identify the users' desired values that are either reflected or missing in the existing Bangladeshi agriculture mobile apps. We manually analyzed 1522 reviews from 29 existing Bangladeshi agriculture apps in Google Play by following a widely used human values theory, Schwartz's theory of basic human values. Our results show that users of the selected apps have twenty one (21) desired individual values where eleven (11) values are reflected in the apps and ten (10) values are missing. This research provides a basis for the developers to design apps that consider users' values. It also provides a direction on which values they should address while developing apps. Moreover, repeating this research in different domains or societies would result in society-oriented apps that are more sensitive to users' values.

KEYWORDS

Mobile Apps, Human Values, Review Analysis, Society-Oriented Applications Development

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1 INTRODUCTION

Software is ubiquitous in all aspects of human life. Therefore, it is essential to consider human values in software. However, human values are not usually taken into account in the development process of software. Software Engineering (SE) research and practices also pay limited attention to the majority of human values [34]. As a result, incidents of value breaches in software are occurring fre-quently. For example, The Volkswagen CEO had to resign because of deceptively designed software to fool fuel emission tests. This was effectively a contradiction of the company's corporate value of "responsible thinking" and resulted in a 30% drop in the company's stock price and a 25% drop in sales within a year [29].

Value breaches in mobile applications (apps) can be even more problematic as the use of apps is increasing day by day. Nowadays, people use smartphones as an entry point to the virtual world [8]. To date, more than 2 million apps are available both in the Google Play Store and the Apple App Store [3]. As smartphones become more personal to their users, a breach of human values, such as safety or privacy, in these mobile apps can lead to serious consequences. For example, Instagram has been accused as partly contributing to the suicide of a British teenager [7]. This incident enforced Instagram to remove self-harm or suicide images from its platform [28]. Another example is the Facebook-Cambridge Analytica scandal. Facebook has been blamed for allowing over 50 million of their users' personal information to be collected and harvested by Cambridge Analytica without user consent [5]. As a consequence, Facebook's CEO was scrutinized in front of the U.S. Congress [25], Facebook lost over 119 billion U.S. dollars in its market value [31] and it was fined more than 5 billion U.S. dollars by the Federal Trade Commission (FTC) and the Information Commissioner's Office (ICO) [2].

The above-mentioned incidents show the urgency of the consideration of human values in mobile apps development. With this in mind, we conducted a case study of Bangladeshi agriculture mobile apps. We analyzed user reviews to explore users' desired values from those apps as well as to identify the reflected and missing desired values. The motivation for this case study came from a project named PROTIC (Participatory Research and Ownership with Technology, Information and Change), a partnership between Oxfam Bangladesh and Monash University [35]. This project works for the poor, marginalized and vulnerable people in rural Bangladesh to accelerate their economic development and empowerment through smartphones [43].

In this study, we analyzed users' reviews because feedback in the form of reviews is a source of information for the developers [27]. Reviews provide information on feature requests, experiences

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with new features, suggestions for improvements and details about user requirements which can guide developers to better meet users' preferences [16]. We did not take star ratings into account because these tend not to reflect users' values. Moreover, star ratings are given for the whole app, not for a particular feature; therefore, it is difficult to understand how users feel about a particular feature [16].

In this research, 1522 reviews from 29 Bangladeshi agriculture apps were collected from a web crawler named 'WebHarvy' [17]. The reviews were manually classified to relate with human values based on a human values theory which is explained in detail in section 2. Each review was coded and analyzed manually by not only matching the words with values but also reflecting on the semantics of the reviews. The classification and analysis based on values were challenging because of the abstract and ill-defined nature of values [34]. This issue was mitigated by the expertise of the raters, all of whom were experts on human values in SE.

As an outcome, the study found 21 desired individual values of users from the Bangladeshi agriculture apps. Among them, 11 individual values were already present and 10 were missing in the apps. The contribution of this study is to provide a basis for the app developers to consider human values, particularly to give a direction on which values should be addressed while developing apps. The method of this study can be replicated for apps in other countries.

Table 1: Value categories and descriptions [41]

Value Category	Description (motivational goals)
Self-direction	Independent thought and action–choosing, creating, exploring
Stimulation	Excitement, novelty, and challenge in life
Hedonism	Pleasure or sensuous gratification for oneself
Achievement	Personal success through demonstrating competence according to social standards
Power	Social status and prestige, control or dominance over people and resources
Security	Safety, harmony, and stability of society, of relationships, and of self
Conformity	Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms
Tradition	Respect, commitment, and acceptance of the customs and ideas that one's culture or religion provides
Benevolence	Preserving and enhancing the welfare of those with whom one is in frequent personal contact
Universalism	Understanding, appreciation, tolerance, and protection for the welfare of all people and for nature
Holistic View	Human values considered holistically without focusing on predetermined values

2 BACKGROUND

Human values are *"important as guiding principles in life"* [37]. Values are something that reflect people's personal and social preferences [4, 37]. Social scientists have conducted research to conceptualize human values since 1950 [40]. For example, in 1973, Rokeach categorized values into goals in life and mode of conduct which he named as terminal values and instrumental values respectively [36, 37]. He found 18 terminal values and 18 instrumental values [37]. Similarly, Hofstede conducted several studies to work with values among employees of different subsidiaries of the same multinational business organization [18–21]. In 1992, Schwartz introduced his theory of basic human values which recognized 10 main human value categories measured using 58 individual value items [38, 39]. This theory has been developed and validated using data from 82 diverse countries around the world irrespective of geography, culture, language, religion, age and gender [41]. Parashar et al. (2004) introduced the micro and macro concept of values which are individual behaviour and cultural practices respectively [33]. Gouveia et al. introduced the three-by-two framework with six basic value categories and 3 specific values under each category [15].

Human values need to be considered in Software Engineering (SE) as SE is becoming a vital part in every sector of our daily lives. There are only a few studies that operationalize human values in SE. For example, *Values-First SE* provided more visibility to the interplay between SE choices and underlying human values [10]. In another study, Ferrario et al. introduced the *Values Q-sort* method that aims to measure developers' values in SE [46]. More commonly, software engineering practice has paid little attention to human values except for well-known quality attributes such as *security*, *privacy* or *accessibility* [45]. Similarly, there is very little research on human values in mobile apps. Exceptions are the application of the *Value-Sensitive Design (VSD)* framework to analyze reviews of mobile apps for a diabetes self-management app [8] and an adolescent mobile safety app [14].

In this research, Schwartz's theory of basic human values has been used to analyze users' values expressed in the reviews of existing Bangladeshi agriculture apps. Schwartz is the most cited and widely applied theory of human values not only in the social sciences but also in other disciplines [11, 42]. For example, this theory has been used in Computer Science [1, 30] and SE research [11]. Furthermore, this theory clarifies not only the components of human values but also how people's value priorities might differ [36]. The 10 main value categories in this model are categorized based on their motivational goals (see Table 1) and measured from 58 individual value items [41]. Schwartz created a circular structure with these 10 main value categories along with the 58 individual value items as shown in Figure 1. In Schwartz's values theory, values located close to each other are congruent and further apart are opposite in nature [38, 41].

3 METHODOLOGY

This research investigated the user reviews of Bangladeshi agriculture mobile apps with the aim to explore users' desired values and to identify which values are reflected in the apps and which are missing.

We conducted this study with Android apps as Android dominates 83% of the market share of smartphones [14, 24]. This research intends to address the three following research questions:

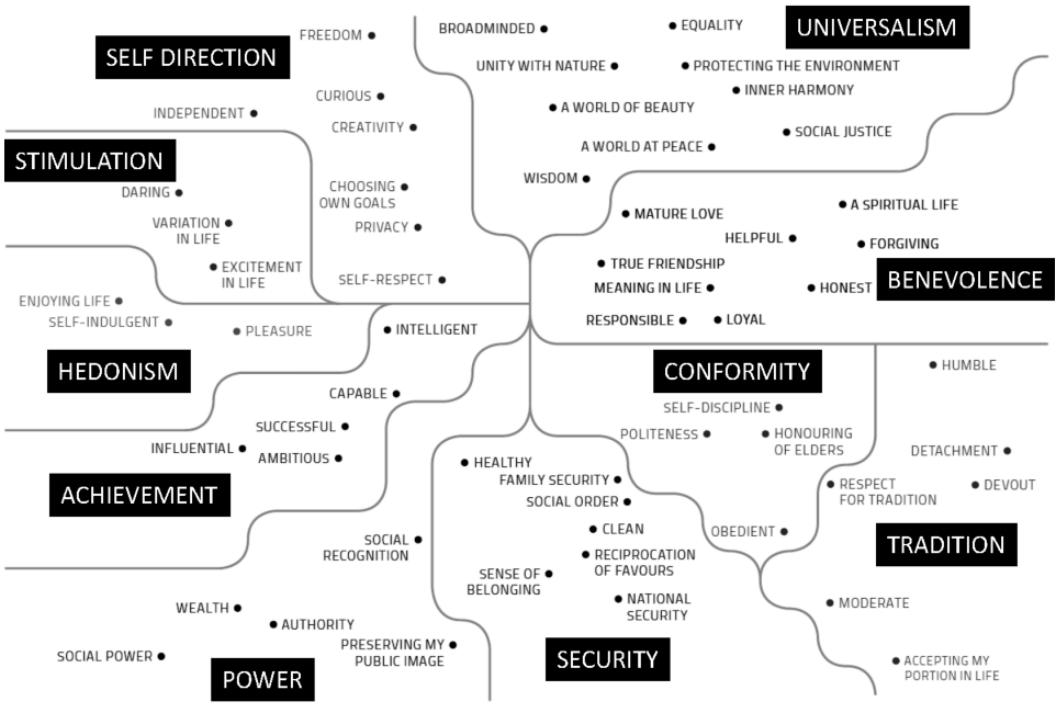

Figure 1: Theoretical model of basic human values by Schwartz [6, 38]

(RQ1) For Bangladeshi agriculture mobile apps, what values are desired by the users?
(RQ2) Which of those desired values are missing in the existing Bangladeshi agriculture apps?
(RQ3) To what extent are the desired values present in the existing Bangladeshi agriculture apps?

A manual analysis of user reviews was performed instead of adopting automated tools because automated tools cannot detect language nuances (e.g., sarcasm) [32], which are very common in user reviews. For example, we found a review that states, "The app is not working on my new phone. Wow great!!". Though the words 'Wow' and 'Great' are related to praise and can be related to the Schwartz value *Pleasure*, this review is nothing but sarcasm where *Pleasure* is actually missing. Moreover, we found many reviews with spelling and grammatical mistakes for which we cannot expect accurate results from automated tools. For example, we found a review with a local accent that states, "This is geret af" which actually means "This is a great app". Similarly, many reviews with different local Bengali accents were found. As the annotator is Bangladeshi and aware of the different local accents, the chance of misinterpreting the reviews is reduced.

Among the two available methods for qualitative data analysis (coding and qualitative content analysis [8]), we adopted coding as it is the best way to analyze app reviews [8]. The coding details are explained in subsection 3.2. At first, each review was read and interpreted. Then, relevant information was searched in each review to categorize it (see phase 1 in subsection 3.2) and relevant reviews were related with values according to the process mentioned in phase 2 in subsection 3.2. Figure 2 gives an overview of the research method. The details of data collection and data analysis are described in the following subsections.

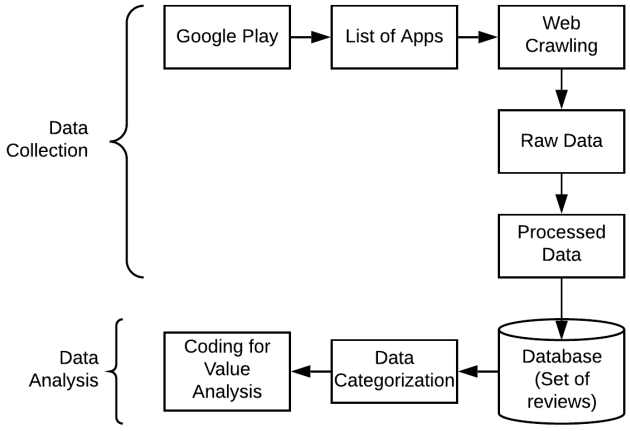

Figure 2: An overview of the research method

3.1 Data Collection

Data collection was conducted in two phases.

Phase 1: Data Extraction

We started our study by searching for Bangladeshi agriculture mobile apps in Google Play. While searching, the item 'apps' was

selected and the keywords 'agriculture', and 'Bangladesh' were given as search terms conjoined with 'and'. The inclusion and exclusion criteria for selecting the applications are shown in Table 2. We collected all the relevant apps manually through this searching scheme. A second iteration of searching was done by using the same keywords but without the conjunction 'and'. Finally, a list of 35 Bangladeshi agriculture mobile apps was created in an online spreadsheet with their names, descriptions, play store ratings, number of downloads, number of raters and Google Play link. The data regarding descriptions, play store ratings, number of downloads and number of raters were saved for future use. The file was last updated in September 2018.

Table 2: Inclusion and Exclusion Criteria for Choosing Mobile Applications from Google Play

Inclusion criteria	Apps of farming
	Apps of livestock
	Apps of farming equipments
	Apps of agriculture online shopping
	Apps of agriculture news
Exclusion criteria	Language other than English and Bengali
	Farming game
	Agriculture examination questions guide for students

For each app, all the user reviews were crawled through a web crawler named 'WebHarvy' [17] on 6 September, 2019. A total of 3991 user reviews along with user ratings on a 1-5 scale and date were crawled and kept in an online spreadsheet. We did not crawl the identity of the reviewers due to privacy reasons. Moreover, this information was not necessary for our research. From the 35 Bangladeshi agriculture apps, 6 apps had no reviews. Therefore, we crawled the data from the rest of the 29 apps. The first 654 reviews were manually checked to ensure if 'WebHarvy' crawled the reviews and corresponding data precisely.

Phase 2: Data Pre-processing

Before proceeding to the data analysis, the database of 3991 reviews and corresponding information was checked manually for irrelevant and meaningless reviews. We found 119 irrelevant and meaningless reviews and removed those manually. We were looking for some constructive reviews that can direct us towards new values rather than compliments only. Therefore, we removed the most common reviews that state one word only such as 'good', 'excellent', 'amazing', 'nice', 'wow', 'great', 'awesome', 'helpful' and 'important'. Let's imagine, these words are 'X'. We also removed the reviews which mention 'It is X', 'The app is X', 'X app', 'Really X', 'Very X' as well as a combination of the given words such as 'Good, awesome, helpful'. Reviews related to the words 'love' and 'like' such as 'Loving it so much' or 'I like it' were also removed. After removing these kinds of reviews, we created a new database of 1522 reviews with the corresponding ratings and date with which we moved forward to the next step. The ratings and date were saved for future use.

3.2 Data Analysis

Data analysis was conducted in the following two phases.

Phase 1: Preparation of Value Analysis

The reviews were manually divided into 'Praise', 'Criticism', 'Problem faced', 'Suggestions', 'Expectations' and 'Queries' for the convenience of relating each review with values. For example, the review stating 'It's a hacking app. It collects personal data' can be placed under 'Criticism' (Hacking app) and 'Problem faced' (Collects personal data). In spite of not mentioning directly about any expectation, the review can also be placed under 'Expectations' as the internal meaning of this review is the expectations of the user for apps to ensure privacy and security. Furthermore, users expect developers to be loyal and honest. As we worked with an abstract topic like values, we tried to think openly and understand the semantics of the reviews. On the other hand, this review has no 'Praise', 'Suggestions' and 'Queries'. Another example is 'Really it is a great app for all farmers or stakeholders who are related to agricultural practice, especially very helpful for students of plant pathology or agriculture! But more pesticides of different companies may be included in it!'. This review reflects 'Praise' as it is great and helpful, gives 'Suggestions' to add more information on pesticides of different companies and has 'Expectations' to get this app being more informative. Similarly the review 'Where can I get hydroponic solution for plants?' can be placed under 'Queries'. All of the 1522 reviews went through this process and were prepared for value analysis.

Phase 2: Value Analysis

Each review was manually classified with 'Present individual value items', 'Present main value categories', 'Desired individual value items' and 'Desired main value categories'. The terms 'Present' and 'Desired' have been used when a value is already reflected in the apps and when users expect a value from the apps, respectively. Phase 1 helped us understand if values are present or desired in the apps. For example, a review that is under the category 'Praise', it is related to 'Present values' and for other categories ('Criticism', 'Problem faced', 'Suggestions', 'Expectations' and 'Queries'), it is related to 'Desired values'. This is explained in Figure 3. After that, to relate each review with specific present/ desired individual value items and main value categories, we analyzed the reviews again according to the Schwartz circular value structure and coded the reviews. We named the values as 'Missing values' that are desired by the users but not present in the apps. In spite of the difficulties of relating the reviews with an abstract concept like human values, we believe the chance of an incorrect interpretation is low as the annotator has a deep knowledge on the Schwartz value structure and conducted similar research on human values in Software Engineering.

As an example of the analysis of reviews and relating to values, consider the above-mentioned review in phase 1. 'It's a hacking app. It collects personal data' does not have any 'Present individual and main values' as it is not categorized under 'Praise'. Rather, it is placed under the category 'Desired values' because of the categorization under 'Criticism', 'Problem faced' and 'Expectations'. Therefore, this review can be related to a few desired individual value items such as *Security*, *Privacy*, *Loyal* and *Honest*. According

to the Schwartz value structure, these individual values are categorized under the main values *Security*, *Self-direction* and *Benevolence* (*Loyal* and *Honest* both are under *Benevolence*) respectively. Similarly the review 'Really it is a great app for all farmers or stakeholders who are related to agricultural practice, especially very helpful for students of plant pathology or agriculture! But more pesticides of different companies may be included in it!' has both present and desired values as it is categorized under 'Praise' as well as 'Suggestions' and 'Expectations'. It has two present individual value items, *Pleasure* and *Helpful* as according to the reviewer, it is great and helpful. These are under the main value categories of *Hedonism* and *Benevolence* respectively. It has also two desired individual value items, *Curious* and *Wisdom* as this review is expecting more information on a particular topic. These values are under the main value categories of *Self-direction* and *Universalism* respectively. Likewise, the review 'Where can I get hydroponic solution for plants?' has a desired value as it is placed under 'Queries'. It can be related to a desired individual value item, *Curious* and the desired main value category *Self-direction*. For better understanding, more examples corresponding to each value are given in Table 3. This table contains the values that we got as outcomes of this research; details are described in section 4.

While doing the analysis, it was found that almost all the reviews can be related to the values, *Pleasure* and *Helpful*, either in 'present individual value items' or 'desired individual value items'. For example, a positive review means the app provides *Pleasure* and it is *Helpful* to the reviewer whereas a negative review means the app lacks *Pleasure* and *Helpfulness*. To solve this issue, only the reviews that contain the words like 'good', 'best', 'nice', 'love', 'like', 'happy' were related to *Pleasure* and the reviews that contain the word 'helpful' are related to the value *Helpful*. As some of the reviews that contain only these words were removed as explained in the phase 2 of subsection 3.1, the problem regarding *Pleasure* and *Helpful* was already solved to a certain extent. Still, there are many reviews that contain these words such as 'I like the weather and climate information of this app' and 'From this app, I can be aware of the market price. This is really helpful for me'. Other than

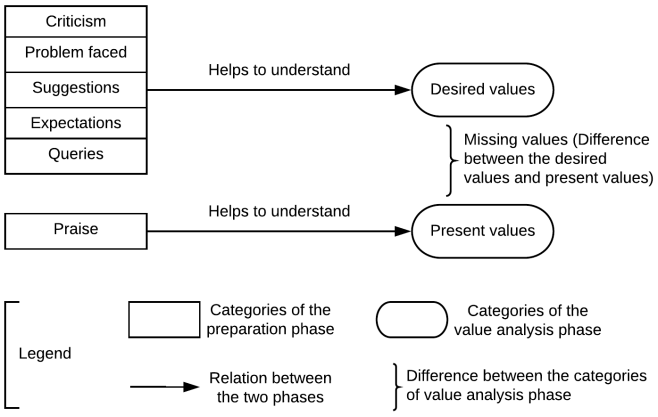

Figure 3: Relations between the preparation phase and value analysis

these kinds of reviews, no review was related to the values *Pleasure* and *Helpful*. There was another challenge to relate the reviews that mention 'Security of the app' to the individual value items. According to the Schwartz value structure, there are two individual value items, *National Security* and *Family Security* under the main value, *Security* but security of the app is neither *National Security* nor *Family Security*. For this case, the individual value item was also kept as *Security* to avoid confusion.

For the whole dataset, the analysis was conducted three times to ensure intra-rater reliability [9].

4 RESULTS

This section presents the results of the review analysis of Bangladeshi agriculture mobile apps. As a reminder, we are exploring the answers of the following three research questions:

(RQ1) For Bangladeshi agriculture mobile apps, what values are desired by the users?
(RQ2) Which of those desired values are missing in existing Bangladeshi agriculture apps?
(RQ3) To what extent are the desired values present in existing Bangladeshi agriculture apps?

4.1 Answering RQ1: Desired Values

Figure 4 shows the desired individual value items of the users of Bangladeshi agriculture mobile apps. From the 58 individual values of the Schwartz circular value structure, users expect 21 values to be reflected in the existing Bangladeshi agriculture apps. According to the figure, the value *Curious* is the most desired value of the users from these apps that are reflected in 26.6% reviews. The second most desired value is *Wisdom* that constitutes 22.0%. The least desired values (0.3%) are *Clean*, *Self-discipline* and *Responsible*.

Similarly, Figure 5 shows the desired main value categories of the users of Bangladeshi agriculture mobile apps. According to the Schwartz value structure, the 21 desired individual value items can be categorized under the 9 main value categories. As there are 10 main value categories in the Schwartz value structure, users expect all of the value categories except *Stimulation*. It is obvious that *Self-direction* is the most desired main value category (36.5%) as it contains the most desired individual value item, *Curious*. Similarly, *Universalism* is the second most desired main value category (24.2%) as *Wisdom* is in this category.

4.2 Answering RQ2: Missing Desired Values

Among the 21 desired individual value items resulting from the result of RQ1, 10 individual values are completely missing in the reviews (1522 reviews) of the 29 apps as shown in Figure 6. Among them, 15.9% users expect the value *Independent* which is the maximum. The noticeable finding is that for all the 8 individual values other than *Clean* and *Self-discipline*, there is little deviation in the percentages of expectations from the reviews.

There are only two desired main value categories that are missing in the existing reviews. These two are *Security* (85.7%) and *Conformity* (14.3%) for the individual value items *Security* and *Self-discipline*. The main value categories that contain the other missing 8 individual values are already reflected due to other present individual value items. For example, *Freedom*, *Independent* and *Privacy*

Table 3: Individual value items with corresponding status (present/ missing) and example of reviews

Status of Values (Present/Missing)	Values	Examples of Reviews
Present desired individual value items	Pleasure	For the first time I got an app what exactly I wanted. Really happy to get this.
	Capable	This app can find the location.
	Respect for tradition	Nice to see an app where all the features including date are written in Bengali. Feeling like I am in a local environment.
	Ambitious	Bangladesh is moving forward, becoming up-to-date. This app is the reflection of it.
	Wisdom	Now I know all the information related to agriculture.
	Wealth	It saves my money as I came to know about pest control by parching with minimum cost.
	Curious	Through this app, I came to know which seeds are good.
	Helpful	It is helpful for the farmers as it makes their job easy.
	Responsible	After adding my crops information in the app, it notifies me fortnightly what I should do to take care of the crops.
	Creativity	It contains Leaf Color Chart (LCC), now I can match the color of the leaves of my plants.
	Intelligent	An intelligent, innovative and game changing platform for farming community.
Present individual value items that are not desired	Unity with nature	The app gives weather prediction and climate information.
	Protecting the environment	Thanks for giving green economy.
	Healthy	It provides information on crops disease control.
	Social recognition	The app is laudable. For this app, farmers got their identities.
	True friendship	This app is the true friend of farmers.
	Influential	A potential and promising app.
Missing desired individual value items	Freedom	Why Internet connection is needed?
	Independent	It is not working on Android9. As it is an agriculture app, it should be platform independent.
	Clean	It is not well-organized, lots of redundant information.
	Successful	Regular monitoring and updated information are needed to make this app successful.
	Equality	This is not for all, only for the smart farmers.
	Security	It's a hacking app.
	Privacy	It collects personal data.
	Loyal	Rather giving useful information, it is actually marketing its own product.
	Honest	Only gives information of medicines of ACI company (owner of the app).
	Self-discipline	I didn't find any index of the app.

are under the main value category, *Self-direction* which is already reflected because of other individual value items, *Curious* and *Creativity*.

4.3 Answering RQ3: Reflecting Desired Values

There are 11 desired individual value items that are present in the existing Bangladeshi agriculture apps among the 21 desired individual values resulting from RQ1. The proportion of the presence of each of these 11 values is shown in Figure 7. The figure shows the desired value *Wisdom* has the maximum presence which is 53.1% (1051 out of 1522 reviews), which means that 1051 reviewers think existing apps are informative, enhance their knowledge and thus meet their value, *Wisdom*. *Curious* and *Pleasure* are also two values among these 11 which occurred the most after *Wisdom*, 17.9% and 13.6% respectively. The value *Intelligent* has the minimum occurrence (0.1%) among all.

Figure 8 shows the desired main value categories that are present in the existing apps. As *Wisdom* is under the main value category *Universalism*, the occurrence of *Universalism* is the maximum (54.5%). Similarly, for the individual value items *Curious* and *Pleasure*, the main value categories, *Self-direction* and *Hedonism* have the second and third highest occurrences, 18.2% and 13.6% respectively.

5 DISCUSSION

From section 4, it is clear that users expect 21 individual value items to be reflected in the Bangladeshi agriculture apps (subsection 4.1). As 11 of them are already present in the existing apps (subsection 4.3), there is an opportunity for the missing 10 values (subsection 4.2) to be included in the development process of

Bangladeshi agriculture apps. For this purpose, Table 1 might be helpful for the developers to understand the values and their corresponding meanings. We have further interesting observations from this study which are described below.

Observation 1:

There are 6 individual value items that are present in the existing apps but not desired by the reviewers as shown in Figure 9. Among them, *Unity with nature* and *Healthy* have a substantial amount of occurrences, 48.8% (296 out of 1522 reviews) and 42.5% (258 out of 1522 reviews) respectively. As reviewers praised the apps for providing these values, the question can be asked, why do not they expect these values? In our opinion, this is because users might already get a few features from the apps which gave them the feeling of *Unity with nature*, *Healthy* and other 4 values, therefore they did not mention these values as expectations. For this reason, developers should be careful about these values as well while developing future apps.

Observation 2:

There are 11 desired individual value items that are present in the existing apps as shown in Figure 7. One question can be raised that if these values are already present, why do the users expect these values again? In our opinion, these 11 values are related to several features of the apps. For a single value, if the users get one of the corresponding features, it can be reflected through their reviews in the present value category but if the other corresponding features of that value are missing, it can also be reflected from their reviews as desired value.

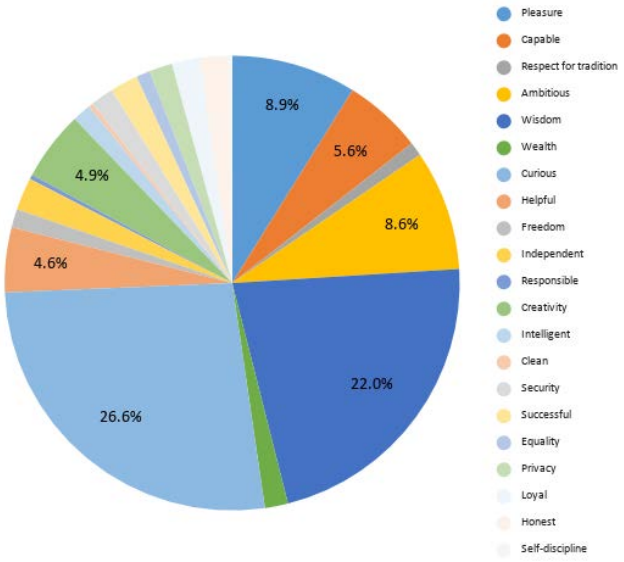

Figure 4: Desired individual Value items

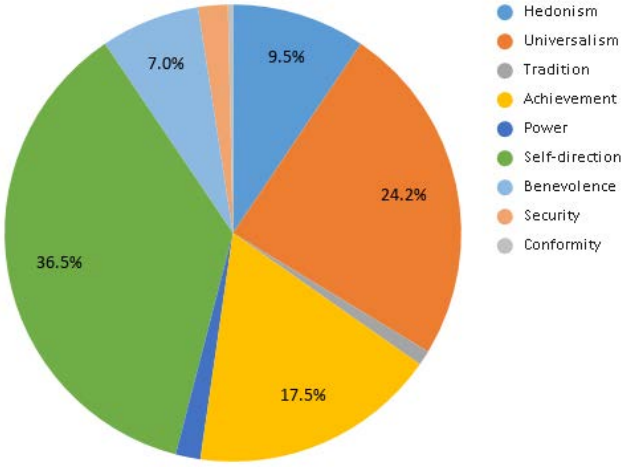

Figure 5: Desired Main Value Categories

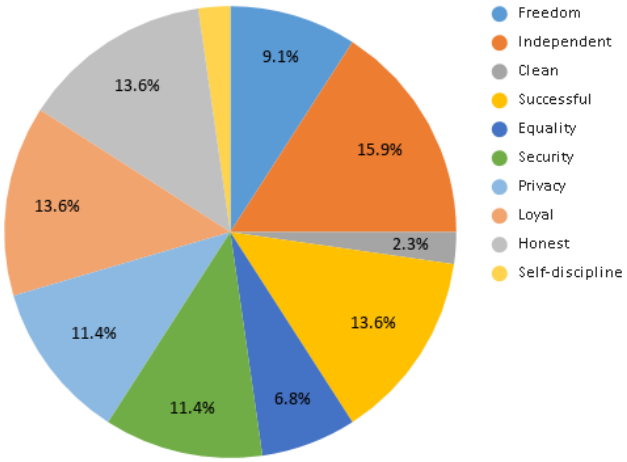

Figure 6: Desired individual Value items that are missing

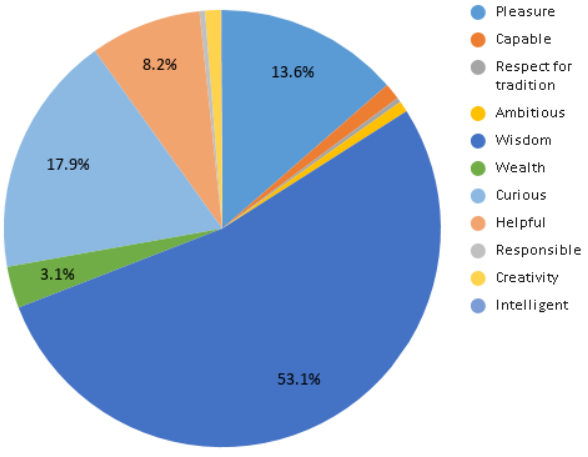

Figure 7: Desired individual Value items that are present

Observation 3:
After completing the analysis, we observe an interesting trend regarding the number of occurrences of more than one value per review and one value per review irrespective of the status of the values (present/ desired). In both cases, the number of occurrences of more than one value per review is greater than the number of occurrences of one value per review as shown in Table 4. This trend reflects that the number of constructive reviews are high that can be analyzed to have better ideas regarding values.

6 THREATS TO VALIDITY

6.1 Internal Validity

There is a threat in working with an abstract topic such as values. Because of the ill-defined nature of values [34], researchers can interpret values differently. Therefore, it can be argued that there is a chance that the review classification scheme is influenced based on the understanding of values of the annotator. Nevertheless, we believe that the chance is very low as the annotator has expertise in human values and experience in conducting similar research.

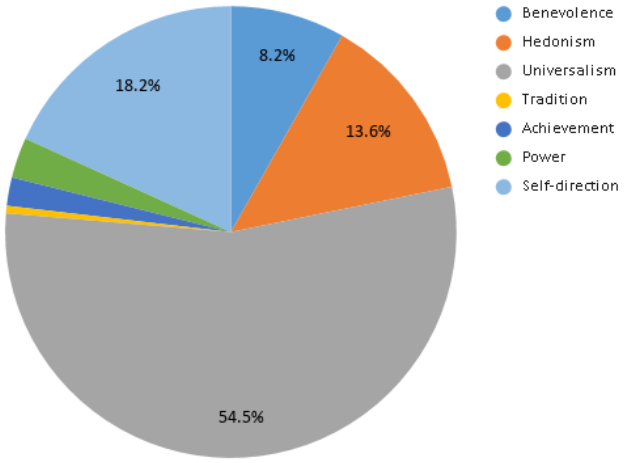

Figure 8: Desired main value categories that are present

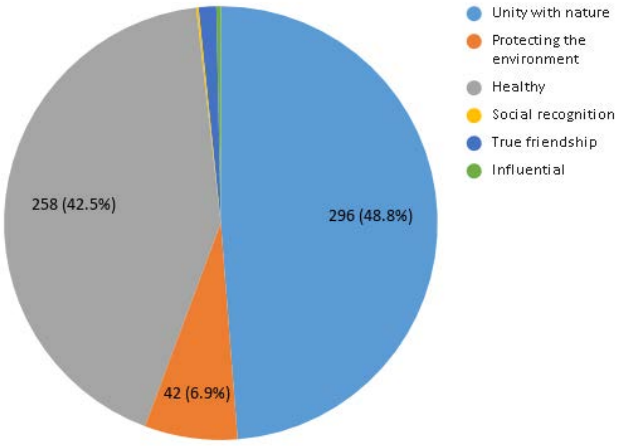

Figure 9: Present individual value items that are not desired by the reviewers

Table 4: Occurrences of present and desired for more than one values, one value and no value per review

Status of Values (Present/Desired)	No. of Values Per Review	No. of Occurrences
Present Values	More than 1 value per review	804
	1 value per review	591
Desired Values	More than 1 value per review	100
	1 value per review	58

6.2 External Validity

One of the limitations of this study is that the outcome cannot be applied to all kinds of apps. As we found the values by analyzing the reviews of the existing Bangladeshi agriculture mobile apps, these values should be considered in the development of Bangladeshi agriculture apps only. The values are expected to be different for apps other than Bangladeshi agriculture apps but we believe, the reviews of any app can also be analyzed to get the values for that app with the same methodology we followed in this research (subsection 3.2).

6.3 Construct Validity

(1) Threats may arise from the number of annotators for this research. Among 1522 reviews we classified, there are 1194 reviews written in Bengali and 328 reviews in English. As automatic translation is not always reliable and does not know the local Bangladeshi accent, the annotator for this research must be a Bangladeshi who knows Bengali and different local accents as well as has expertise in analysing social aspects of Software Engineering. For this reason, all the reviews are analyzed by one Bangladeshi researcher who has expertise in qualitative data analysis specifically on human values based software engineering and has fluency in the Bengali language (mother tongue). To avoid the possible threats of analyzing the whole dataset by a single researcher and to meet intra-rater reliability [9], all the reviews have been analyzed three times by the same researcher. While doing a second iteration, the outcome of 209 out of 1522 reviews needed to be changed which is 13.7% and during the 3rd iteration, the outcome of only 11 (less than 1%) reviews needed to be changed.

(2) Categorizing reviews in terms of values can be argued as there are no well-defined classification techniques for values. Furthermore, as the classification was done by following a specific value structure (The Schwartz circular value structure) shown in Figure 1, there is a chance that the annotator might forcefully relate the reviews with any of the Schwartz values even if the reviews can be related to some other values which are not mentioned in Schwartz value structure.

7 RELATED WORK

This section is divided into the following three subsections.

7.1 Schwartz Values Theory in SE and Other Domains

Other than social science research, Schwartz's theory of basic human values is extensively used in software engineering studies. For example, Mougouei et al. explained the importance of considering human values in software. Schwartz's values theory has been used in this research to define what human values are and how to integrate those values into software which has been termed "operationalizing human values in software" [29]. Schwartz's values theory has also been used in another study to understand the prevalence of human values in publications of four top-tier SE conferences and journals from 2015-2018 [34]. Another research used this values theory to investigate the consideration of human values other than functionality, cost, safety, availability and security in SE [45]. To incorporate human values in the SE decision-making process, Ferrario et al. also used Schwartz's values theory [10]. This theory has also been used in developing a value measurement tool named " Values Q-Sort" to explore the values of developers [46].

Schwartz's values theory has been used in different areas of computer science — for example, in predicting users' movie genre preferences from their psycholinguistic characteristics by analyzing the pattern of their uses of social media [30]; and ethical decision-making theories for companion robots [44].

7.2 Mining App Reviews

App reviews are a useful medium of data to be analyzed in a number of studies. For example, to explore the insights regarding parental control, user reviews of adolescent mobile safety apps have been analyzed [14]. Similarly, over one million user reviews of AppStore have been analyzed to determine the pattern of the reviews, when and how users provide reviews and the relation of the reviews with the number of downloads and the ratings [32]. Iacob et al. extracted mobile apps feature requests by analyzing user reviews with the help of an automated tool [23]. Similarly, requirements have been explored by analyzing user reviews through automatic topic extraction [13]. Another study investigated users' satisfaction by analyzing reviews [26]. Fu et al. proposed a system named 'WisCom' that can analyze over 10 million user ratings and reviews of mobile apps to identify inconsistent reviews, to investigate the reason of liking or disliking an app and to provide insights on the overall app market [12].

7.3 Value and Sentiment Analysis

Few studies of app store data mining explore users' values and sentiments by analyzing user reviews. For example, Dadgar and Joshi schematically coded user reviews of diabetes apps by applying Value-Sensitive Design (VSD) to identify users' (patients with diabetes) values and proposed design techniques that consider users' values [8]. Similarly, sentiment analysis on user reviews of apps has been carried out in several studies to classify user reviews and to inspire the design of review analytics tools [27]; to explore the influence on product-purchasing decisions [22]; and to identify users' sentiments about particular features that lead to group fine-grained features into high-level features [16].

8 CONCLUSIONS AND FUTURE WORK

In our study, we found that almost half of the expected values of users are missing in existing Bangladeshi agriculture apps. According to our case study, out of twenty one (21) desired individual values of the users, eleven (11) values are reflected in existing apps whereas the rest of the values are absent. This result can encourage developers to consider users' desired values while developing apps, particularly giving a direction towards which values they should address while developing Bangladeshi agriculture apps. The methodology followed in this research can be applied to apps developed for other countries.

In the future, we hope to increase the sample size by collecting more reviews from apps of other platforms and app stores. We will also involve more than one annotator for the validation of the review analysis. Furthermore, we expect to conduct the same study on the agriculture mobile apps of other developing countries to observe the cultural differences. This will provide an opportunity to compare apps of different countries and their corresponding values.

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