# UTILISATION OF INDIGENOUS FRUIT TREE SPECIES WITHIN THE LAKE VICTORIA BASIN, RWANDA

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## *ABSTRACT*

*This study was conducted in Bugesera, Kirehe and Nyamagabe districts of Rwanda within the Lake Victoria Basin (LVB) to document the available edible indigenous fruit trees (IFTs), prioritise IFTs, document the determinants for their preferences and examine local uses of the keystone IFTs. A total of 300 farmers familiar with IFTs were interviewed face to face using semi-structured questionnaires. A total of 12 focus group discussions (FGDs) were conducted. Questionnaire responses were coded, entered and analyzed using SPSS. Generated themes from qualitative data were subjected to content analysis. A total of 13 IFTs was recorded in the sampled districts. Highly prioritized IFTs were Ximenia caffra, Garcinia buchanani, Parinari curatellifolia, Pappea capensis, Anona senegalensis, Myrianthus holstii, Carisa edulis and Lannea schimperi. Age, occupation and income of the farmers significantly influenced preference of IFTs. Major uses of IFTs included food, medicine, firewood and timber. There is a need to include the preferred IFTs in the agricultural programme since they are perceived as valuable resources.*

## *Key words:*

*Indigenous fruit trees, rural community, food security, livelihood.*

## 1. INTRODUCTION

Indigenous fruit trees (IFTs) play a vital role in the livelihoods of many rural communities in Africa who periodically rely on agriculture [1]. They contribute tremendously to household food security, nutritional health and income especially during harsh times (2, 3]. IFTs provide rural communities with products such as oil, medicine, nuts and fodder [4]. Besides socio-economic importance, some IFTs are protected by local communities for ecological reasons such windbreaks [5].

IFTs also play an important agroforestry initiative and they are viewed to a larger context as multipurpose trees, hence their integration into in agroforestry systems [1]. However, despite

their significance, a few IFTs are exploited [6] within and outside Lake Victoria Basin of Rwanda. This study therefore aimed at documenting the IFTs in LVB, Rwanda; prioritizing the available edible IFTs and documenting the determinants for their preferences, and lastly examining the local uses of the keystone IFTs.

Gathering of such information is deemed as a major step for more informed and rational decision making about the management of these IFTs. In addition, local knowledge related to benefits of IFTs can help in planning and directing developmental research and extension programs by providing useful information for policy formulation [7, 8]. As utilization of IFTs depends on indigenous knowledge [9], there is a need to collate information from local communities that can help up scaling domestication of IFTs in the LVB.

# 2. METHODS

Data were collected from three purposively selected districts of Rwanda namely Bugesera (-2° 8' 44" S, 30° 5' 29" E), Kirehe (-2°15'23.72" S, 30°43'34.21" N) and Nyamagabe (-2°24'29.48" S, 29°28'4.69" N) that lies within the LVB (http://rw.geoview.info). Available anecdotal information indicates that these three districts have rich flora with relatively abundant IFTs. Two sectors within each district were purposively selected for the survey. In each sector, two cells were randomly selected, and in each cell, two villages were also randomly selected for questionnaire administration. All in all, a total of eight villages were selected from each district for the household survey with the selected household representatives (household head or any other household member deemed fit to response to the questionnaire). A total of 300 farming household members were interviewed face to face using semi-structured questionnaires. Diagnostic surveys were conducted on the farms in order to have an inventory/explore the availability of IFTs. A total of 12 focus group discussions (FGDs) were conducted in the three study districts to prioritise (rank) available edible IFTs and also validate the questionnaire responses. In order to have divergent views from participants, parallel discussions were held with about 8 - 15 male and female participants respectively. Only three top prioritized IFTs in each district during the survey and FGDs were highlighted and given flow for investigation on utilization.

Questionnaire responses were later coded, entered and analysed largely descriptively using SPSS. Regression analysis was also performed to assess the socio-economic determinants (age, sex, marital status, level of education, occupation and income) of peoples' choices of IFTs. Qualitative data from FGDs was grouped into categories to generate themes and subjected to thorough content analysis [10, 11].

# 3. RESULTS

## 3.1. Socio-Demographic Characteristics Of The Respondents

Mean age of the respondents in the study areas was 42±14 and most of them (55.7%) were males. Regarding marital status, a big number of the respondents (83.9%) are those who were married. It is also important to note that 56.8% of the respondents had attained primary education but practice farming (99.7%) as their main occupation. Besides, 92.7% of the respondents have land. The mean time spent in the village was 23±19 whereas 29±37 was the mean monthly income of the respondents in Rwanda.

Table 1. Socio-demographic characteristics of the respondents

| | **Bugesera (N=100)** | **Kirehe (N=100)** | **Nyamagabe (N=100)** | **Total (N=300)** |
|---|---|---|---|---|
| **Age (Years)** | | | | |
| Mean±SD | 38±12 | 39±12 | 49±17 | 42±14 |
| Min | 18 | 21 | 21 | 18 |
| Max | 70 | 73 | 100 | 100 |
| Median | 36 | 38 | 47 | 40 |
| **Sex (%)** | | | | |
| Male | 49 | 67.4 | 51.5 | 55.7 |
| Female | 51 | 32.6 | 48.5 | 44.3 |
| **Marital status** | | | | |
| Single | 8.2 | 6.1 | 5 | 6.4 |
| Married | 83.5 | 89.9 | 78 | 83.9 |
| Divorced | 1.0 | 1.0 | 1 | 1.0 |
| Widowed | 7.2 | 3.0 | 16 | 8.3 |
| **Level of education (%)** | | | | |
| None | 27.8 | 20.2 | 59.2 | 35.5 |
| Primary | 64.9 | 66.7 | 37.8 | 56.8 |
| Secondary | 7.2 | 13.1 | 2 | 7.4 |
| College | - | - | 1 | 0.3 |
| **Main occupation (%)** | | | | |
| Farming | 100 | 98.4 | 100 | 99.7 |
| Civil service | - | - | - | - |
| Business | - | 1.1 | - | 0.3 |
| Others | - | - | - | - |
| **Have land** | | | | |
| Yes | 84.7 | 97 | 97 | 92.7 |
| No | 15.3 | 3 | 3 | 7.3 |
| **Period stayed** | | | | |
| Mean+SD | 18±16 | 11±6 | 38±20 | 23±19 |
| Min | 0 | 1 | 1 | 0 |
| Max | 65 | 33 | 89 | 89 |
| Median | 14 | 11 | 36 | 15 |
| **Monthly income** | | | | |
| Mean±SD | 13±19 | 39±56 | 7±12 | 29±37 |
| Min | 0 | 0 | 0 | 0 |
| Max | 114 | 286 | 71 | 286 |
| Median | 7 | 14 | 3 | 7 |

***SD: Standard Deviation***

### 3.2. Available indigenous fruit trees (IFTs) in LVB, Rwanda

A total of 13 IFTs was recorded in the three surveyed districts of Bugesera, Kirehe and Nyamagabe. In Bugesera district, we recorded the highest number (11) of ITFs species, followed by Kirehe district (10 species) and the lowest number (1 species) in Nyamagabe district (Table 2). Only 9 IFT species were recorded the same in districts of Bugesera and Kirehe. Two species such as *Acokanthera schimperi* and *Haplocoelum foliolosum* were unique to Bugesera district while *Anona senegelensis* was unique to Kirehe district. Two species (*Ancylobotrys amoenia* and *Carisa edulis*) were represented in the same family (Apocynaceae).

Table2. Available IFTs in Bugesera, Kirehe and Nyamagabe districts of LVB, Rwanda.

| Scientific name | Local name | Family name | Bugesera | Kirehe | Nyama gabe |
|---|---|---|---|---|---|
| *Ximenia caffra* (Sond.) | Amasasa | Olacaceae | √ | √ | |
| *Ancylobotrys amoenia* (Hua) | Amakamire | Apocynaceae | √ | √ | |
| *Parinari curatellifolia* (Planch. ex Benth.) | Amanazi | Chrysobalanaceae | √ | √ | |
| *Sytrychnos sp.* | Amahonnyo | Loganiaceae | √ | √ | |
| *Garcinia buchananii* (Baker) | Amasarasi | Clusiacee | √ | √ | |
| *Lannea schimperi* (Hochst. ex A. Rich.) | Imimuna | Anacardiaceae | √ | √ | |
| *Pappea capensis* (Eckl. & Zeyh.) | Imimena | Sapindaceae | √ | √ | |
| *Carissa edulis* (Forssk.) Vahl) | Iminyonza | Apocynaceae | √ | √ | |
| *Anona senegalensis* (Pers.) | Imisharamariya | Annonaceae | | √ | |
| *Dovyalis macrocalyx* (Oliv.) Warb.) | Imitegengeri | Salicaceae | √ | √ | |
| *Myrianthus holstii* (Engl.) | Imyufe | Urticaceae | | | √ |
| *Acokanthera schimperi* (A. DC.) Schweinf.) | Umusagwe | Gentianales | √ | | |
| *Haplocoelum foliolosum* (Hiern) Bullock | Imijwiri | Sapindaceae | √ | | |

### 3.3. Prioritized indigenous fruit trees (IFTs) in LVB, Rwanda

Individual ranking of IFTs (Table 3) shows that *X. caffra* (22.35%), *C. edulis* (15.05%) and *G. buchananii* (13.97%) were three top prioritized IFTs species in Bugesera district. In Kirehe district, *P. capensis* (27.05), *P. curatellifolia* (25.92%) and *L. schimperi* (18.97%) were highly preferred IFTs species. In Nyamagabe district, *M. holstii* (92.2%) was the only edible IFT species available in the area.

On the other hand, pairwise ranking (group ranking) of IFTs during FGDs also indicated the preference of *G. buchananii* (16.00±3.00), *P. curatellifolia* (15.5±8.5) and *X. caffra* (15.00±6.00) over other IFTs species in Bugesera district. However, *A. amoenia and L. schimperi* do not appear on the list of IFTs for pair wise ranking because the activity started by cleaning the list of IFTs mentioned by respondents during the household survey. These two IFTs were therefore unknown by the participants who were present during FGDs.

In Kirehe district, pairwise results indicate that *P. curatellifolia* [22.50±3.50] was highly ranked followed by *A. senegalensis* [16.00±6.00] and *X. caffra* [13.50±1.50]. Likewise, during the ranking activity, there were IFTs species that did not appear in the list since they were not known by the participants in group discussion.

Table 3. Prioritisation of IFTs

| | Individual ranking of IFTs | | | Pairwise ranking | | | |
|---|---|---|---|---|---|---|---|
| **District** | **IFTs** | **Ranking score (%** | **Rank** | **Mean (±SEM) score*** | | **Total mean score** | **Rank** |
| **Bugesera (N=100)** | *X. caffra* | 22.35 | **1st** | 8.50±2.50 | 6.5±3.5 | 15.00±6.00 | **3rd** |
| | *G. buchananii* | 13.97 | **3rd** | 7.50±0.50 | 8.50±2.50 | 16.00±3.00 | **1st** |
| | *C. edulis* | 15.05 | **2nd** | 5.00±0.00 | 7.50±2.50 | 12.50±2.50 | **5th** |
| | *P. capensis* | 10.5 | **5th** | 6.00±1.00 | 1.50±1.50 | 7.50±2.50 | **6th** |
| | *Sytrychnos sp.* | 11.7 | **4th** | 4.0±4.0 | 9.50±1.50 | 13.50±5.50 | **4th** |
| | *A. amoenia* | 6.12 | **8th** | - | - | - | - |
| | *P. curatellifolia* | 8.7 | **6th** | 7.5±2.50 | 8.00±6.00 | 15.5±8.5 | **2nd** |
| | *H. foliolosum* | 3.87 | **9th** | 0.50±0.50 | 7.00±2.00 | 7.50±2.50 | **7th** |
| | *D. macrocalyx* | 0.95 | **10th** | 0.50±0.50 | 2.50±2.50 | 3.00±3.00 | **9th** |
| | *A. schimperi* | 6.45 | **7th** | 0.50±0.50 | 4.00±4.00 | 4.50±4.50 | **8th** |
| **Kirehe (N=100)** | *P. curatellifolia* | 25.92 | **2nd** | 10.00±1.00 | 12.50±2.50 | 22.50±3.50 | **1st** |
| | *P. capensis* | 27.05 | **1st** | 2.00±2.00 | 5.50±3.50 | 7.50±5.50 | **4th** |
| | *L. schimperi* | 18.97 | **3rd** | 1.50+0.50 | 3.50±2.50 | 5.00±3.00 | **7th** |
| | *X. caffra* | 11.37 | **4th** | 7.00±1.00 | 6.50±0.50 | 13.50±1.50 | **3rd** |
| | *C. edulis* | 7 | **5th** | 4.50±1.50 | 2.50±1.50 | 7.00±3.00 | **5th** |
| | *A. amoenia* | 2 | **7th** | - | - | - | - |
| | *Sytrychnos sp.* | 3 | **6th** | 2.50±1.50 | 3.00±1.00 | 5.50±2.50 | **6th** |
| | *G. buchananii* | 1.8 | **8th** | 3.50±3.50 | 1.00±0.00 | 4.50±3.50 | **8th** |
| | *A. senegalensis* | 1.05 | **9th** | 6.00±6.00 | 10.00±0.00 | 16.00±6.00 | **2nd** |
| **Nyamagabe (N=100)** | *M. holstii* | | **1st** | | | | |

## 3.4. Factors influencing people's preference of indigenous fruit tree species

Logistic regression analysis showed that age, level of education, occupation and income were the main determinants of the choices people made on IFTs species (Table 4). Age ($R^2$=0.054, P=0.003) positively influenced peoples' preference of *G. buchananii*. Age (P=0.016), level of education (P=0.012), occupation (P=0.017) and income (P=0.006) significantly influenced preference of *M. holstii* ($R^2$=0.181). On the other hand, only occupation and income had positive influence on people's preference of *P. curatellifolia* ($R^2$=0.119, P=0.008 and P=0.000) whereas the preference of *P. capensis* was influenced by education, occupation and income ($R^2$=0.145, P=0.040, P=0.006, P=0.00). Only age influenced people's preference of *C. edulis* ($R^2$=0.073, P=0.046). Monthly income was also the factor influencing community preference of *L. schimperi* ($R^2$=0.105, P=0.000) in Rwanda.

Table 4. Logistic regression of socio-economic determinants of peoples' choices of IFT species in LVB, Rwanda

| Factors | *G. buchananii* | | *X. caffra* | | *M. holstii* | | *P. curatellifolia* | | *P. capensis* | | *C. edulis* | | *L. schimperi* | | *A. senegalensis* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OR | Sig. | OR | Sig. | OR | Sig. | OR | Sig. | OR | Sig. | OR | Sig. | OR | Sig. | OR | Sig. |
| Age | 0.949 | 0.003* | 0.976 | 0.054 | 1.030 | 0.016* | 1.00 | 0.975 | 0.993 | 0.593 | 0.967 | 0.046* | 0.988 | 0.507 | 1.031 | 0.279 |
| Sex | 1.131 | 0.746 | 0.883 | 0.699 | 0.964 | 0.912 | 0.935 | 0.837 | 1.165 | 0.635 | 1.071 | 0.856 | 0.752 | 0.558 | 1.504 | 0.607 |
| Marital status | 1.312 | 0.395 | 1.346 | 0.244 | 1.009 | 0.973 | 0.804 | 0.451 | 0.582 | 0.078 | 0.591 | 0.185 | 1.176 | 0.686 | 0.560 | 0.393 |
| Level of education | 1.076 | 0.817 | 1.405 | 0.184 | 0.498 | 0.012* | 1.577 | 0.084 | 1.711 | 0.040* | 1.335 | 0.359 | 1.725 | 0.126 | 1.940 | 0.297 |
| Occupation | 0.812 | 0.527 | 0.889 | 0.662 | 0.494 | 0.017* | 2.196 | 0.008* | 2.261 | 0.006* | 1.562 | 0.168 | 1.674 | 0.164 | 1.222 | 0.730 |
| Income | 0.993 | 0.300 | 0.999 | 0.837 | 0.979 | 0.006* | 1.018 | 0.000* | 1.016 | 0.001* | 0.999 | 0.841 | 1.020 | 0.000* | 0.957 | 0.316 |

* = significant at $p \leq 0.05$, $R^2$=0.054 (*G. buchananii*), $R^2$=0.032 (*X. caffra*), $R^2$=0181 (*M. holstii*), $R^2$=0.119 (*P. curatellifolia*), $R^2$=0.145 (*P. capensis*), $R^2$=0.073 (*C. edulis*), $R^2$=0.105 (*L. schimperi*), $R^2$=0.020 (*A. senegalensis*).

## 3.5. Other determinants of the preference of IFTs species

Other determinants of the IFTs species cited by the people included their availability (abundance), high food (fruits) potential, market potential, medicine value, organoleptic taste (sweetness), ability to grow fast and produce edible parts, environmental benefits and other services the species provide (Table 5). The preference of *G. buchananii* was mostly determined by high food potential of the fruit (32.8%). The same factor highly determines the choice of *X. caffra* (36.1%), *C. edulis* (40%), *P. curatellifolia* (29.3%), *L. schimperi* (56.5%) and *A. senegalensis* (54.5%). The preference of *M. holstii* is mostly determined by environmental benefits (45.9%) whereas the choice of *C. capensis* is mostly determined sweetness (34.9%).

Table 5. Other determinants of the preferred IFTs in Rwanda (%)

| IFTs | N | Availability (abundance) | High food (fruits) potential | Productivity/high yield | Medicine value | Market potential | Sweetness | Ability to grow fast and produce edible fruits | Environmental benefits | Other multiple services |
|---|---|---|---|---|---|---|---|---|---|---|
| *G. buchananii* | 58 | 13.8 | 32.8 | 12.1 | 8.6 | 1.7 | 19 | 10.3 | 1.7 | |
| *X. caffra* | 72 | 11.1 | 36.1 | 4.2 | 6.9 | | 29.2 | 6.9 | 5.6 | |
| *C. edulis* | 50 | 12 | 40.0 | 2.0 | 20.0 | | 22.0 | 2.0 | 2.0 | |
| *M. holstii* | 98 | 3.1 | 26.5 | 18.4 | 4.1 | | 1.0 | 1.0 | 45.9 | |
| *P. curatellifolia* | 82 | 15.9 | 29.3 | | 12.2 | | 26.8 | 7.3 | 3.6 | 4.9 |
| *P. capensis* | 106 | 12.3 | 26.4 | | 16.0 | | 34.9 | 1.9 | 3.7 | 4.7 |
| *L. schimperi* | 92 | 42.4 | 56.5 | | 1.1 | | | | | |
| *A. senegalensis* | 11 | 45.5 | 54.5 | | | | | | | |

## 3.6. Local uses of the keystone indigenous fruit trees (IFTs) species in LVB, Rwanda

Table 8 indicates wide array of local uses of the preferred IFTs species in LVB of Rwanda. The prominent uses of IFTs recorded were food, medicine, firewood, and timber. In all the benefits, it is clearly indicated that food was the most recorded use for all the species. In fact, the fruits of IFT species are eaten as food by the people or can be processed into juice. The species are also valued for the medicine they provide. This comes as the second major use of the species. Other benefits recorded during the survey were firewood and timber.

Table 6. Reported major uses of keystone IFTs

| **IFTs** | **Major uses** | |
|---|---|---|
| | **Uses** | **%** |
| ***X. caffra (=90)*** | Food | 87.8 |
| | Medicine | 20.0 |
| | Firewood | 2.2 |
| ***C. edulis (=40)*** | Food | 77.5 |
| | Medicine | 17.5 |
| | Firewood | 2.5 |
| | Timber | 2.5 |
| ***G. buchananii (=55)*** | Food | 87.3 |
| | Medicine | 12.7 |
| ***M. holstii (N=99)*** | Food | 83.8 |
| | Medicine | 12.1 |
| | Firewood | 4.0 |
| ***P. curatellifolia (N=86)*** | Food | 80.2 |
| | Medicine | 16.3 |
| | Firewood | 3.5 |
| ***P. capensis*** | Food | 80.2 |
| | Medicine | 19.8 |
| ***A. senegalensis (N=51)*** | Food | 62.7 |
| | Medicine | 23.5 |
| | Firewood | 11.8 |
| | Timber | 2.0 |
| ***L. schimperi*** | Food | 87.1 |
| | Medicine | 12.9 |

## 3.7. Knowledge on food use and medicinal value of preferred IFT species in LVB, Rwanda

Results on food use of preferred IFTs indicate that the species provide fruits that are eaten ripe (Table 7). Besides, fruits of some IFT species can be processed into juice which is also consumed by people as beverage. Regarding the consumers of the fruits and juice, *G. buchananii* and *M. holstii* were reported to provide fruits that are eaten by all categories of people (children and the elderly). Information from FGDs was that children are the most consumers of these fruits. They therefore contribute to food security of people. Results from the survey also indicate that people show a big interest on the food value from IFTs. To all the IFT species except *A. senegalensis*, the level of interest of IFTs as food is very high.

Table 7. Reported food value of keystone IFTs

| IFTs | Food value | Part used as food (%) | | Level of interest of IFTs as food | | |
|---|---|---|---|---|---|---|
| | | | % | | N | % |
| ***X. caffra*** | -They are edible<br>-Can be processed into juice | Ripe fruit (83) | 100 | **High** | 30 | 38.0 |
| | | | | **Medium** | 27 | 34.2 |
| | | | | **Low** | 22 | 27.8 |
| ***C. edulis*** | Edible (children and elderly), Processed into juice | Ripe fruit (49) | 100 | **High** | 14 | 40.0 |
| | | | | **Medium** | 6 | 17.1 |
| | | | | **Low** | 7 | 20.0 |
| | | | | **Not at all** | 8 | 22.9 |
| ***G. buchananii*** | -Eaten fresh by children, women and men<br>-Can be processed into juice | Ripe fruit (50) | 100 | **High** | 20 | 38.5 |
| | | | | **Medium** | 12 | 23.1 |
| | | | | **Low** | 18 | 34.6 |
| | | | | **Not at all** | 2 | 3.8 |
| ***P. curatellifolia*** | -Edible<br>-Juice processed when fruits are ripe | Ripe fruit (85) | 100 | **High** | 32 | 41.0 |
| | | | | **Medium** | 17 | 21.8 |
| | | | | **Low** | 28 | 35.9 |
| | | | | **Not at all** | 1 | 1.3 |
| ***P. capensis*** | Fruits are eaten fresh | Ripe fruit (94) | 100 | **High** | 42 | 44.7 |
| | | | | **Medium** | 23 | 24.5 |
| | | | | **Low** | 29 | 30.9 |
| ***A. senegalensis*** | Fruits are eaten fresh,<br>-Juice is processed when fruits are ripe | Ripe fruit (2) | 100 | **Low** | (2) | 100 |
| ***M. holstii*** | Fruits are eaten fresh by all categories of people | Ripe fruit (96) | 100 | **High** | 57 | 64.0 |
| | | | | **Medium** | 22 | 24.7 |
| | | | | **Low** | 10 | 11.2 |
| ***L. schimperi*** | Fruits are eaten fresh | Ripe fruit (51) | 100 | **High**<br>**Medium**<br>**Low** | 42<br>23<br>29 | 44.7<br>24.5<br>30.9 |

The preferred IFTs species were also reported to be medicinal. They treat various illnesses. *X. caffra, G. buchananii* and *C. edulis* were reported to treat more ailments than other species. *A. senegalensis, P. capensis* and *L. schimperi* treat fewer illnesses than other species. Malaria and digestive disorders are the major ailments treated by almost all the IFT species. Different parts of the species such as leaves, roots, fruits, bark, flowers, seeds and sap were reported to be used in treating ailments. Medicine is prepared and administrated in different ways depending on the part used and the illness to be treated. From the results, chewing the fruit and leaves, boiling the bark with water, drinking the juice were the major methods of medicine preparation. Apparently, the level of interest of IFTs as medicine tends to be medium. Only *G. buchananii* (6.7%) and *C.*

*edulis* (42.6%) were reported to be the species towards which communities show a high level of interest as medicine. People show a very low level of interest of A. senegalensis was medicine (100%).

Table 8. Reported medicinal value of preferred IFTs

| IFTs | Medicinal value | | | | | | |
|---|---|---|---|---|---|---|---|
| | Illnesses treated | Parts used | | Preparation of medicine | Level of interest as medicine | | |
| | | | % | | | N | % |
| ***X. caffra*** | -Digestive disorders<br>-Malaria,<br>-Cough<br>-Given to persons poisoned | Leaves (9) | 34.6 | -Leaves are chewed or boiled with water<br>-Raw fruit is mixed with juice/ water<br>-Fruits eaten raw as snack | High | 5 | 11.1 |
| | | Roots (9) | 34.6 | | Medium | 10 | 22.2 |
| | | Fruit (3) | 11.5 | | Low | 12 | 26.7 |
| | | Flowers (1) | 3.8 | | Not at all | 18 | 40.0 |
| | | Seeds (4) | 15.4 | | | | |
| ***G. buchananii*** | -Treatment of intestinal worms (for babies) | Leaves (1) | 6.7 | -Drinking juice (ripe fruit) | High | 20 | 6.7 |
| | -Malaria, digestive disorders | Roots (3) | 20.0 | -Decoction and syrup | Medium | 12 | 4.0 |
| | - Stomachaches | Fruit (10) | 66.7 | -Eating the ripe fruit | Low | 18 | 6.0 |
| | -Cough | Seeds (1) | 6.7 | -Chewing the leaves | Not at all | 2 | 0.7 |
| ***C. edulis*** | -Fever | Leaves (3) | 11.5 | -Bark boiled with water (cough) | High | 20 | 42.6 |
| | -Measles | Roots (18) | 69.2 | -Juice from fruits is mixed with water | Medium | 8 | 17.0 |
| | -Worms | Fruit (1) | 3.8 | | Low | 17 | 36.2 |
| | -Malaria | Seeds (4) | 15.4 | | Not at all | 2 | 4.3 |
| ***P. curatellifoli*** | Stomachaches | Leaves (2) | 6.2 | Leaves, roots and bark are boiled with water | High | 6 | 15.8 |
| | Malaria | Roots (23) | 71.9 | | Medium | 11 | 28.9 |
| | | Seeds (7) | 21.9 | | Low | 12 | 31.6 |
| | | | | | Not at all | 9 | 23.7 |
| ***P. capensis*** | Digestive disorders | Leaves (4)<br>Roots (23)<br>Bark (3)<br>Seeds (31)<br>Sap (1) | 6.2<br>35.9<br>4.7<br>48.4<br>1.6 | Chewing leaves | High<br>Medium<br>Low<br>Not at all | 17<br>24<br>10<br>10 | 27.9<br>39.3<br>16.4<br>16.4 |
| ***A. senegale*** | -Intestinal worms | Roots (1) | 0.3 | | Low | 1 | 100 |
| | -Diarrhea | Seeds (1) | 0.3 | | | | |
| | -Skin | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | diseases (scabies) | | | | | | |
| | | | | | | | |
| **P. capensis** | -Digestive disorders | Leaves (4)<br>Roots (23)<br>Bark (3)<br>Seeds (31)<br>Sap (1)<br>All parts (2) | 6.2<br>35.9<br>4.7<br>48.4<br>1.6<br>3.1 | -Boiling the bark or leaves (to treat digestive disorders) | High<br>Medium<br>Low<br>Not at all | 17<br>24<br>10<br>11 | 27.4<br>38.7<br>16.1<br>17.7 |
| **L. schimperi** | Cough | Leaves (3)<br>Roots (12)<br>Bark (1)<br>Seeds (24) | 7.5<br>30.0<br>2.5<br>60.0 | Chewing the leaves or eating the fruit | High<br>Medium<br>Low<br>Not at all | 14<br>16<br>11<br>1 | 33.3<br>38.1<br>26.2<br>2.4 |
| ***M. holstii*** | Malaria, intestinal worms, stomachaches | Leaves (1) | 1.8 | Eating the raw fruit/ syrup from the juice | High | 3 | 4.3 |
| | | Roots (1) | 1.8 | | Medium | 18 | 25.7 |
| | | Fruit (55) | 96.5 | | Low | 33 | 47.1 |
| | | | | | Not at all | 16 | 22.9 |

# 4. DISCUSSION

## 4.1. Inventory of indigenous fruit trees

There is a diversity of IFTs in Rwanda. Bugesera district in eastern side of the country has more IFTs than other districts due to their savanna vegetation. In fact, there is a densely shrubby savanna covering the hills and grassy savannas covering the dry valleys in the area. The species identified are therefore found in the drylands of the savanna in the district. Kirehe is at the second rank to have diverse IFT species. One reason for the place to have a diversity of IFT species is that the big eastern side of the district where the study took place got settled recently. It was covered by the forest and the savanna grass before people came to settle there. The fact that the place was newly settled, some fruit tree species remained in people's land when they were clearing the forest for settlement and expansion of agricultural activities. They were therefore kept in their lands and near their homes. A number of species identified in Bugesera and Kirehe are the same. In fact, the two districts located in eastern side of the country have savanna vegetation and drylands as something common that favors a diversity of indigenous fruit tree species. In Kirehe district additionally, there is a wide forest on the side of Tanzania bordering Kirehe district. This makes also the district have IFTs diversity.

Nyamagabe which was reported to have one species is located in western side of the country. The district is close to Nyungwe National Park. Though this park is on top in wild plant species diversity, there is overexploitation and inappropriate use of land by people whose agriculture is the main economic activity in the area [12]. Around the park, there is serious extinction of different species [13]. Thus, *M. holsti* is the only edible IFT species found in communities' land. It was also reported during the FGD that this fruit tree species is propagated in the area. People are interested in domesticating it in their lands for a number of benefits.

Some wild species identified in Rwanda are also found elsewhere outside the country. In a survey conducted, *Strychnos* species and *P. curatellifolia* for example were for example identified as the top regional priority species in southern and sub-Saharan Africa [14]. In addition, in one of the surveys conducted in Uganda, *C. edulis, A. senegalensis* are among the common IFT species [15]. All these species are the major recognized and valued IFTs in Central and East Africa [2]. There is therefore a need to promote the domestication of these IFTs in different places of Rwanda.

## 4.2. Prioritization of the available IFTs and determinants for their preferences

There is no big difference in prioritization of IFTs during the survey and focus group discussion. This means some species that were prioritized during individual ranking also appeared in the top three species prioritized during FGDs. These are species like *X. caffra*, *P. curatellifolia* and *G. buchananii*. These species are also among the prioritized species in both districts such as Bugesera and Kirehe. There is a need for sustainable conservation of these species through on-farm domestication, for example. This would make a big number of people know their importance. In Nyamagabe district, no ranking (individual and pairwise ranking) was done because *M. holstii* was the only IFT in the area.

Different factors influence people's preference of IFTs. Age was one of the factors that influenced the preference of IFTs in Rwanda. The more people get old, the more knowledge on wild plants they have. Other studies also revealed that adults have more knowledge on indigenous and wild plants compared to young people [16]. The reason for the knowledge on the species might be because adults are often in interaction with wild species looking for medicine or other products. Level of education is another factor influencing people's preference of IFTs. In fact, through reading and research, people get to know much about the IFT species. The more people are therefore educated, the more knowledge on the species they have. Besides, occupation and income also influence the people's preference of IFTs. This implies that having a given profession or occupation and the amount of money earned monthly play a big role in prioritizing IFTs by rural communities.

There are other different determinants for prioritization of IFTs. In Rwanda, these reasons for preference of IFTs are associated with the importance of IFTs. This means that most of the reasons for preference of IFTs indicated in Table 7 were reasons related to the use of prioritized species. The surveyed reasons for preference indicate that food potential appears to be the mostly reported reasons for fruit tree species preference in Rwanda. Food potential as a determinant to IFTs preference is in line with different studies. Other studies also revealed that rural communities prefer species that significantly contribute to their diet due to their richness in vitamins and minerals [2, 17]. There is therefore a need to encourage people to domesticate IFTs as a way of diversifying farming crops and hence contribute to food security.

## 4.3. Local uses of the keystone IFTs

In Rwanda, like other in places in LVB, IFTs are given value by the local people. These are the ones who know them and can attribute value to them. The prioritized species provide a lot of benefits to people. Food, medicine, firewood and timber were reported as the main uses of the species. In addition to these benefits, other uses such as income, charcoal, shade, erosion control and fodder were also reported during FGDs. This shows that the preferred IFT species can play a great role in the livelihood of people because of the multiple roles they provide. The uses of IFTs were also noted in other studies. In Kenya for example, IFTs have multi functions which are very useful for various means [6]. In Uganda, IFTs are also given high value for their multiple functions they provide to people [18].

Food and medicine were the highly reported uses of IFTs in Rwanda. The IFT species produce fruits which are consumed by not only human beings but also wide animals. Apart from being eaten as food, they are used as herbal medicine and provide other important needs to people. These results are similar with those found in different studies. One study revealed that IFTs like *P. curatellifolia* provide edible fruits which contain vitamins and essential mineral for the proper maintenance of human health [19]. The same study stated that the species is rich in proteins, fats, carbohydrates and minerals. Besides, *X. caffra* was also identified for food and medicine. The food uses of the species have also been emphasized in other studies which stated that the species is rich in vitamins, proteins and minerals [20]. To this end, IFTs are generally supplemental and emergency contribution to household food supply [21, 22]. They thus contribute to food security.
IFTs are not only perceived as food benefit providers but also valued for herbal medicine. Results above indicate that common medicinal uses include treatment of malaria, stomachaches, digestive disorders, worms and cough. Leaves, roots, fruit and bark are different parts of the species used by local communities to cure various ailments. In short, rural communities rely on the IFTs because they offer broad health benefits as it has also been strongly emphasized in other studies [23, 24]. Results also indicate that IFTs (*G. buchananii, P. curatellifolia, A. senegalensis* and *M. holstii*) are the source of income and provide many other services such as timber, firewood, charcoal and shade, etc.

# 5. CONCLUSION

IFTs in Rwanda are perceived as very important due to numerous roles they play in the communities' lives. Though most of them grow wild, they are considered as sustainable plant species with nutritive, medicinal, economic values etc in rural communities of Rwanda. Having a look at the information provided during household survey and FGD, IFTs contribute a lot to communities' livelihood. Therefore there is a strong need to widespread the knowledge on importance of IFTs. There is also a need of clear policy on raising communities' awareness on on-farm domestication and management of IFTs. Advocating for the management of IFTs can lead to broad knowledge on the benefits of the species. Based on these findings, we also propose research institutions have effective strategies about IFTs especially the prioritized ones. These strategies may include domestication and plantation, promoting indigenous knowledge about IFTs and promoting marketability of IFTs.

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