

## Article

# Perceptions on Sack Gardening in Rural Areas: The Case of Vegetable Stakeholders in Koutiala and Bougouni, Mali

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**Abstract:** Understanding the perception of sack gardening technology is important in order to better support the adoption of sack gardening in households, given the nutritional role vegetables play. This notwithstanding, research has not yet been carried out to understand the stakeholders' perception of sack gardening technology in the zones of Bougouni and Koutiala, where sack gardening technology was introduced under the Africa Research in Sustainable Intensification for the Next Generation (Africa-RISING) project. This study assessed the perception of farm households on sack gardening technology and specifically to understand to what extent this innovation responds to household needs. Q-methodology was used to identify rural household's viewpoints and principal component analysis (PCA) was performed to compare stakeholders' opinion typologies to discourses retained by Q-method results. Focus group discussions were used to identify the statements used for the q-set in the individual surveys. Our findings showed three factors or discourses which reflected the stakeholders' viewpoints. A nutritional role, the role of making vegetables available for household consumption and the role of environment protection, specifically soil protection, were indicated in the stakeholders' opinions. The understanding of the different discourses retained provides insights that can be used to design public and private interventions to support the usage of the technology in households or the adoption of this technology.

**Keywords:** sack gardening; balanced diet; environment protection; stakeholders' discourses; Mali



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## 1. Introduction

A complete and balanced diet includes the daily use of fresh vegetables (vegetables and fruits), rich in the minerals, vitamins and amino acids necessary for human health [1–3]. The nutritional deficit in households, if these products are not provided, causes serious health problems, especially among children [4]. In several regions of Mali and mainly in the Sikasso region, considered the country's grain basket, malnutrition issues in households remains a serious concern [5,6]. Households that consume vegetables are suffering less from child malnutrition issues [4]. Vegetables and fruits in the diet strengthen the immune system [5,6]. However, access to land to produce vegetables, in order to respond positively to household needs for vegetable consumption is a challenge. Indeed, in Africa, south of the Sahara and particularly in Mali, problems related to land are very recurrent and more of the poor population do not have access to land for agricultural production and men have more access to land than women [7,8]. It is necessary to have great means in order to access land or to pay a rental amount to landowners before exploiting the land [7]. On the other side, agricultural lands are increasingly exposed to climate shifting consequences [8]. Agricultural lands are exposed to the problems of degradation and of the low fertility of crop lands. In addition, women, who have great responsibilities in households, do not

have access to land to allow her household to benefit daily from a balanced diet. As it is, it may seem difficult for households to adequately meet their daily needs in vegetables for a balanced diet [8,9].

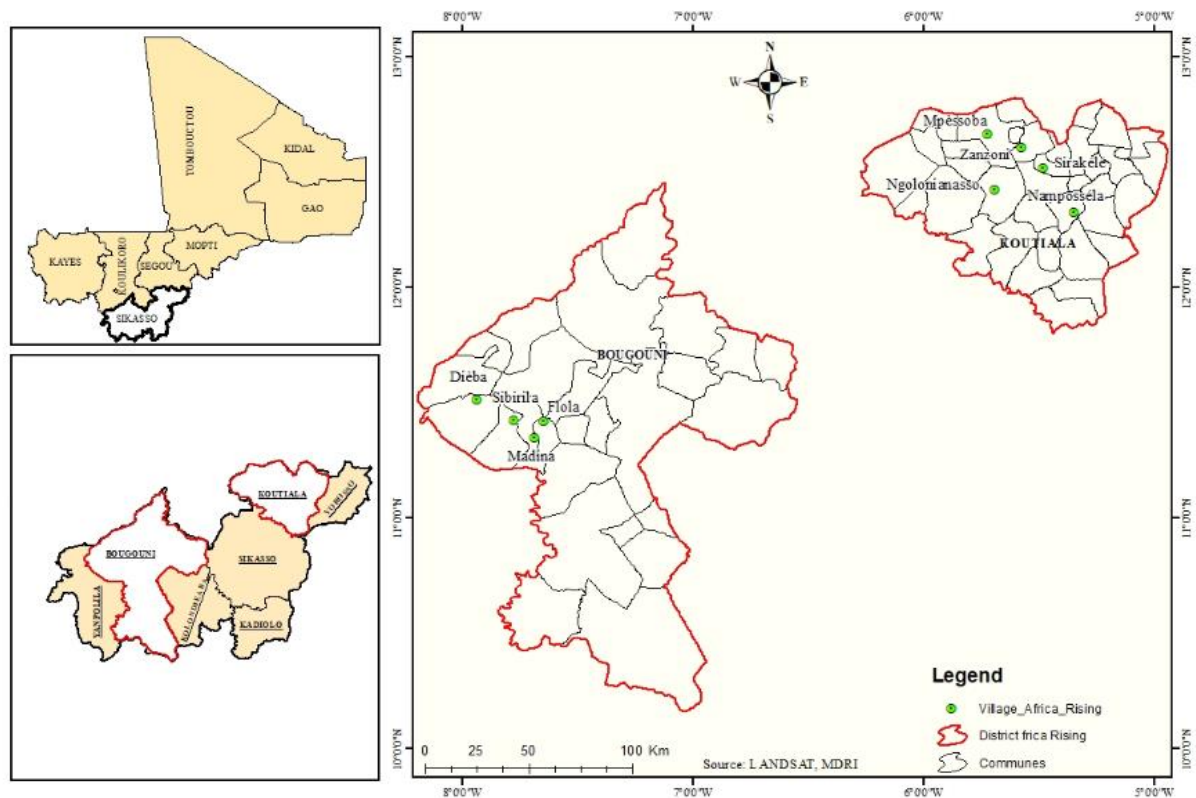
To help households and especially women in the role of family protection and to ensure a balanced diet for children, innovations that allow agricultural production around housing concessions seem more sustainable in the context of the difficulty in accessing agricultural land. Sack gardening responds to this requirement [4,10]. Sack gardening as its name suggests, or soil-less gardening, is the type of gardening in which vegetables are transplanted into biodegradable sacks, filled with soil for garden production. Sack gardening is mostly practiced in areas where there is difficulty in accessing productive land [10]. This type of gardening is implemented to help communities that have difficulty in accessing productive land to produce vegetables for consumption by families. It can be easily implemented in and around households for easy supervision. This type of gardening appears to be a great opportunity for households, especially in rural areas, to respond to the issues of a balanced diet. This technology has been implemented since 2018 under the Africa-RISING project in the circles of Koutiala and Bougouni under the project title "Sustainable intensification of key farming systems in the Sudano-Sahelian Zone of West Africa". With respect to this innovation, scholars have little information regarding the perception of populations that have used the technology. The identification of households' perceptions regarding this technology may support its scaling up for the improvement of food security and may allow policy makers to specifically orientate their actions towards promoting this technology in communities to limit the issues of malnutrition among households.

The main research question of the present study is to understand how households' perceptions regarding sack gardening may allow the scaling up of the technology to reduce malnutrition and to improve food security in rural areas where land access is a challenge. To respond to this query, the Q-method was used in our methodological framework. The Q-method is a mathematical method, most commonly used in social science to understand stakeholders' perceptions regarding a specific concept [11,12]. In this study area, no study on the perception of stakeholders regarding sack gardening has yet been carried out. The study will, therefore, inform policy decisions for a better implementation of this innovation to improve livelihoods and households' food security.

## 2. Materials and Methods

### 2.1. Study Area

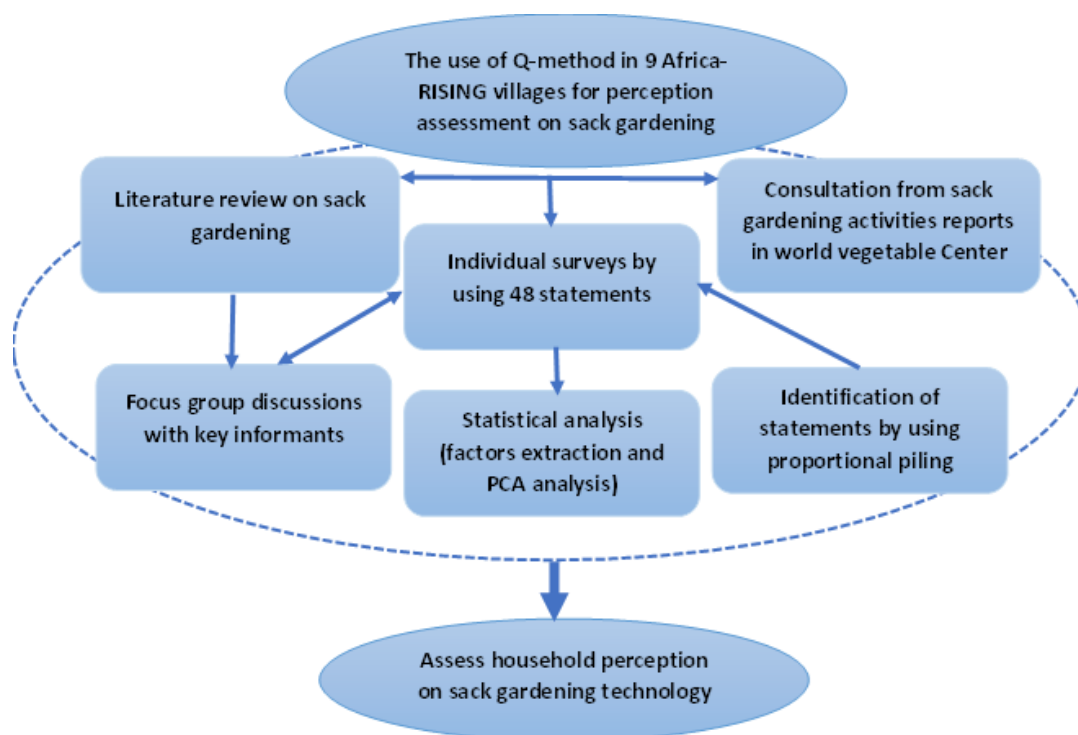
The study covered the 9 villages of the Africa-RISING project in the circle of Bougouni in the villages of: Madina, Dieba, Sibirila and Flola and in the circle of Koutiala in the villages of: Mpesoba, Naposela, Sirakele, Zanzoni and N'golonianasso (Figure 1). In these villages, sack gardening is practiced mainly for household consumption. In each village, the technology was popularized by WorldVeg, which identified vegetable producers (women and men) per Africa-RISING village in 2018. The two circles selected by the project were recommended for gardening production and are located in the southern part of Mali where the rainfall varies from 600 mm to 1000 mm. Bougouni district (11°25'0" N 7°29'0" W) covers an area of 20,028 Km<sup>2</sup> with an estimated population of 59,679 and the global acute malnutrition rate of 18.6%. The circle of Koutiala (12°23'22" N, 5°27'50" W) covers an area of 18,000 Km<sup>2</sup> with an estimated population of 137,919 and global acute malnutrition rate of 17.02%.



**Figure 1.** Image of Africa-RISING project villages implemented in surveys.

## 2.2. Methodological Framework

To assess the perception of stakeholders on sack gardening, a general methodological framework was used and it is summarized in Figure 2. The methodological framework began with a literature review on sack gardening and by consultation of activity reports in the framework of the Africa-RISING project. The synthesis of this research enabled the identification of a general idea regarding statements that may be used. Indeed, a checklist including reflections around sack gardening was formulated. This checklist took into account: advantages of sack gardening, its inconveniences, constraints to using this technology, its nutritional roles, environmental protection roles, its vegetable provision roles, its water requirement needs, and the ongoing discourses around the technology. This checklist was the entry point to discuss in focus group discussions with key informants (representing youth producers, agricultural agents, representatives of female and male vegetable producers' associations). Focus group discussions allowed for the retention of 48 clear statements that took into account all parameters indicated above. The proportional piling principle was used to identify statements or affirmations around sack gardening that were keenly identified by participants. These statements were inscribed on cards and represented the Q-set used in the individual surveys. The Q-method has been applied in individual surveys. The responses of stakeholders (Q-sorts) were analyzed using Q-method software. Principal component analysis (PCA) was employed for comparison with analysis from Q-method software. These different methods enabled the assessment of opinions from households regarding sack gardening.



**Figure 2.** Methodological framework of households' perception regarding sack gardening technology in 9 villages of Africa-RISING project in Mali.

### 2.3. Surveys in Focus Group Discussion (FGD)

Focus group discussions (FGD) were conducted in the nine villages of the Africa-RISING project. The nine FGDs gathered an average of  $11.5 \pm 3.5$  stakeholders. FGDs allowed identification of statements related to sack gardening. The statements considered the origin of sack gardening, consequences and benefits of sack gardening, social groups that practice this innovation, and some current discourse about sack gardening. For the purpose of individual surveys, 48 statements were selected according to scores obtained by following the proportional piling approach. On a score of 100, the different groups had given scores regarding each statement listed. These selected statements were used to constitute the Q-set. Table A1 shows the different statements selected with scores given by stakeholders to statements. Statements that received at least a score of 60% were retained.

### 2.4. Individual Surveys

Individual surveys were conducted in the 9 villages to understand stakeholders' opinions on sack gardening by following Q-method principles. The 48 statements retained during the FGDs were inscribed on cards. These cards, were given to the interviewee for ranking according to their agreements and disagreements. At the beginning, the purpose of the study was explained to interviewees as well as the ranking process. In the individual surveys, 84 stakeholders were interviewed. Interviewees first divided cards into three piles, the pile of disagreement, the pile of agreement and those of neutrality. Afterwards, interviewees distributed cards according to their degree of agreement and disagreement. The 48 cards were distributed and the Q-sort was recorded. Figure A1 shows an example of card ranking.

### 2.5. Q-Method Implemented in Surveys

The 48 statements inscribed on cards served as the Q-set. For the ranking (Figure A1), these cards were given to the different interviewees for Q-sorting. The Q-sorting grid was established on a scale of 11 (Figure A2). A score of 0 was used if the interviewee had a neutral position regarding a defined statement. A score of  $-5$  indicated total disagreement

and a score of +5 indicate total agreement with the statement. Rankings obtained from the interviewees were called the Q-sorts.

### 2.6. Stakeholders Involved in Surveys

Of the stakeholders involved in the surveys, 72% were women. Women were more involved due to the fact that gardening is actively conducted by women and also because the Africa-RISING project has focused more on women for sack gardening. In this activity, women in the villages have associations and organizations that are more active. However, more than 27% of men were also involved to assess their opinions on sack gardening. Opinions from 5 technicians and researchers were taken into account. Opinions of men, of technicians and researchers did not influence the perceptions from women. Between the number of women and other actors involved in the surveys, a significant difference ( $p < 0.05$ ) was observed. This principle had been respected in the present study as women practice more sack gardening. Then, it would be more relevant to get their opinions and because PCA (principal component analysis) carries out the synthesis of information delivered by respondents.

### 2.7. Statistical Analyses

Analyses were performed with PQ-Method software, version 2.35 specialized in analyses of perceptions on a defined concept. The rankings (Q-sorts) of the different stakeholders were encoded. The first part of the analyses consisted of extracting factors using the principal components method (QPCA). Correlations between factors and the eighteen values were computed to characterize the factors. Factors with eighteen values greater than 1 were retained. A low correlation coefficient between factors indicated those factors were different from each other. The varimax rotation (QVARIMAX) was used to show the structure of factors by maximizing the variances between each factor and distributing these variances among the selected numbers of factors.

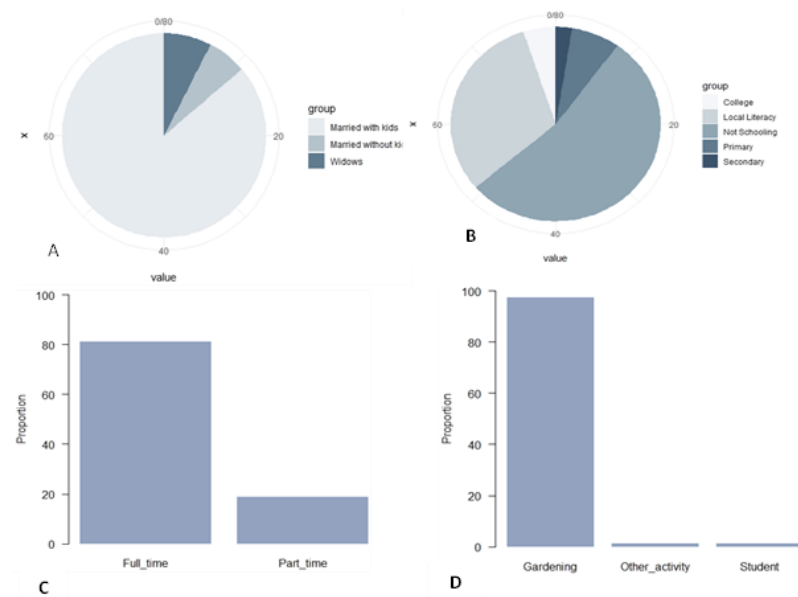
Selected factors were interpreted according to Q-sorts with statistical significance ( $p < 0.05$ ). Factors were retained if there was a strong correlation with at least 3 Q-sorts. For each factor, the rounded mean score for each statement was calculated as the mean score over all Q-sorts assigned to that factor. Interpretation of factors as discourse was made on the basis of the scores obtained indicating agreement or disagreement of the factor with each statement. Q-sorts were classified as consensus between factors when scores obtained did not show a significant difference. A specific definition of a factor was thus related to the significant difference of the scores of the factors with the scores of the other factors.

PCA analysis with FactoMineR and factoextra packages under R was performed for comparing factors extracted after varimax procedure in the Q-method to clusters obtained in the case of the hierarchical classification analysis (HCA). Principal component analysis (PCA) and HCA were performed to cluster stakeholders according to q-sorts. The statements (1, 2, 3 ... 48) were used in columns and the stakeholders (1, 2, 3 ... 84) were used in rows on Excel sheets.

## 3. Results

### 3.1. Stakeholders' Characteristics

The average age of the interviewees was  $46.96 \pm 12.33$  years old and their experience in sack gardening was estimated at  $11.78 \pm 9.88$  years. Figure 3A shows interviewee marital status. Almost 86.2% of interviewees were married with children. The percentage of interviewees married without children was 8.7% and those of widowers (men and women) almost 9.1%. Figure 3B shows that in both circles, gardening and agricultural activities in general are carried out by 61% of stakeholders, who have not received formal education. Almost 30% have received local education.



**Figure 3.** Social characteristics of sack garden stakeholders in Bougouni and Koutiala.

More than 82% of the interviewees practiced agricultural activities full time (Figure 3C). On the other hand, more than 17% devoted part of their time to agricultural activities because they had other activities as mentioned above. This observation shows that support to these stakeholders may be relevant if agricultural sectors are privileged. As women are more involved in gardening production, support to gender in these areas may necessarily be oriented towards gardening activities.

In Figure 3D, we can see that the stakeholders interviewed had gardening as their main activity, and it is practiced by more than 95%. However, we have noted that these farmers combined gardening with other agricultural activities such as rainfed crops and livestock. The majority of them practiced gardening during the dry season. We also note that other off-farm activities were carried out in addition to gardening. Diversification of activities in rural areas allows actors to be more resilient.

### 3.2. Factor's Description

The principal component analysis in the case of Q-method analysis using 84 q-sorts presented eighteen values of 5.1, 4.6, 2.2 and 0.1, respectively, for the first four factors. The three first factors were retained. The varimax procedure for the first three factors was shown as significant with positive correlation with 28, 36 and 9 q-sorts, respectively. The three factors gathered almost 87% of the q-sorts. Correlation coefficients between factors varied from 0.64 to 0.81. The average reliability for the three factors was 0.98. The individual composite reliability was, respectively, 0.99, 0.99 and 0.97 for the three factors retained.

### 3.3. Perceptions on Sack Gardening

Consensus statements are those that do not differentiate factors (Table 1). The consensus statements selected were not statistically different from one factor to another ( $p > 0.001$ ). This indicates the non-existence of disagreement between stakeholders. Strong correlations exist between factors, but some statements differentiate them. Consensus between factors indicates the stakeholders were unanimous regarding statements: 1, 4, 23, 33, 19, 25, 45. From these consensuses, we noted that stakeholders all agreed on the fact that sack gardening is more practiced by women, sack gardening responds to the nutritional needs of households and that the nutritional deficits of children can be easily remedied by adopting the sack gardening practice. In fact, a group of women stated in the survey that: "With this close type of gardening, we have condiments every day to make sauce and it does not require enough means to have your gardening". Elsewhere, a group of women nicknamed

sack gardening as “Akli Sigi”, just to mention that with sack gardening, women do not worry again about the availability of garden produce and the high cost of garden produce, and then it is easier to cook sauce for household consumption. For all interviewees, sack gardening had an economic advantage for households, and could always ensure the daily needs in garden produce.

**Table 1.** Consensus of the different stakeholders around sack gardening.

N°	Statements	F1	F2	F3
1 *	Sack gardening is a technology developed to address the problem of malnutrition in households	5	5	4
4	With sack gardening, women may better take care of their garden because of its proximity	2	2	2
10 *	Compared to ordinary gardening, sack gardening reduces water use from 2 to 1 time	0	0	0
14 *	Vegetables from sack gardening may not be used frequently to respond to household needs	−1	−1	−2
19 *	Sack garden produce is of better quality	2	1	2
23 *	Sack gardening does not appear to be advantageous for women to respond to the nutritional needs of households.	0	1	1
25 *	With sack gardening, households can be less dependent on the price volatility of vegetable products	0	0	0
33 *	The land lack issue met by women is no longer an issue with sack gardening	2	2	3
40	Plants disease risks are limited in sack gardening	0	0	1
45 *	Women are willing more to adopt this innovation	4	4	3

Note: All listed statements are non-significant at  $p > 0.01$  and those flagged with an \* are also non-significant at  $p > 0.05$ .

### 3.3.1. Statements Distinguishing the First Group

In Table 2, are the registered statements that differentiate the stakeholders of the first discourses (factor 1). As we may see, these stakeholders agreed with statements 22, 21, 38, 3 and disagreed with statements 11, 28, 24, 37. We thus note that, while these stakeholders were in favor of the benefits of sack gardening, they were particularly interested in the role sack gardening could play in food security and in the protection of the environment. For proponents of this discourse, sack gardening can contribute to food security (22, 21, 3, 13). Sack gardening can better contribute to soil protection and reduce water use compared to ordinary gardening (26, 16, 39). These different statements place more emphasis on food security, thus putting household nutrition at the forefront. For proponents, the nutritional situation of households can be improved by the implementation of sack gardening. The dimension of household protection through healthy food is put forward. This discourse can therefore be named: “The nutritional role played by sack gardening in households”.

**Table 2.** Statements that differentiate stakeholders in Group 1 from those in Groups 2 and 3.

N°	Statements	F1	F2	F3
22	Sack gardening, if implemented in households, may contribute to nutritional security	5	3	3
21 *	Sack gardening may help households to respond positively to the nutritional deficit of children	4	1	1
38 *	With this close production, households may better feed children without hard work	4	3	3

Table 2. Cont.

N°	Statements	F1	F2	F3
3 *	Sack gardening helps households to better ensure the availability of vegetable products	3	1	0
26 *	In Africa, sack gardening may contribute to better protect the soil as it does not require soil to be worked	2	0	1
16 *	The usage of clean water is preferred in sack gardening production to avoid contamination, particularly by heavy metals, in vegetables	2	4	5
39 *	Sack gardening avoids soil-related constituents	1	0	4
13	Vegetables from sack gardening may be harvested daily to respond to vegetable needs in households	1	2	0
29 *	The practice of sack gardening is more difficult for women	−1	−5	−4
17 *	Sack gardening offers advantages regarding clearing and weeding in technical itinerary of vegetable production	−1	5	−5
2 *	Sack gardening has a foreign origin that does not take into account gardeners' realities in Mali	−1	0	0
37	The usage period of sack gardening is too short to pay attention to it	−2	−2	−3
24	Sack gardening is not an opportunity to eat biological products	−2	−1	−3
28 *	Soil degradation cannot be avoided even if the scaling up of sack gardening is done	−2	−1	−5
11	Compared to ordinary gardening, sack gardening does not reduce water use	−3	−3	−4
34 *	Women have less time to take care of their gardens because of the other household tasks they perform	−3	−4	0
42*	As it is a new innovation, sack gardening is not yet widely adopted	−5	1	−1

Note:  $p < 0.05$ ; asterisk (\*) indicates significance at  $p < 0.01$ .

### 3.3.2. Statements Distinguishing the Second Group

The specific statements for the second factor are shown in Table 3. This factor is characterized by stakeholders who agree with statements 4, 16, 17, 31 and disagree with statements 15, 20, 34, 47. The ins and outs of this discourse indicate time saving in vegetable production by the practice of sack gardening. These stakeholders defend the idea that quality products are obtained from sack gardening because of the quality of water used in watering plants (3, 4, 5 and 16). For these ins and outs, sack gardening is not indicated for commercialization, but allows them to avoid the issue of the lack of land. Thus, with sack gardening, women can better ensure the needs of their families in vegetable products (31, 33). These different statements converge to a discourse that can be named "Sack gardening to respond to household needs in quality vegetables".

Table 3. Statements that differentiate stakeholders in Group 2 from those in Groups 1 and 3.

N°	Statements	F1	F2	F3
17 *	Sack gardening offers advantages in not clearing and weeding in the technical itinerary of vegetable production	−1	5	−5
16 *	The usage of clean water is preferred in sack gardening production to avoid contamination, particularly by heavy metals, in vegetables	2	4	5
8	Water economy is one of the benefits of sack gardening	1	3	2
31 *	Sack gardening is well suited for household consumption and not for commercialization purposes	0	2	0



**Table 3.** *Cont.*

N°	Statements	F1	F2	F3
13	Vegetables from sack gardening may be harvested daily to respond to vegetable needs in households	1	2	0
42 *	As it is a new innovation, sack gardening is not yet widely adopted	−5	1	−1
39 *	Sack gardening avoids soil-related constituents	1	0	4
28 *	Soil degradation cannot be avoided even if the scaling up of sack gardening is done	−2	−1	−5
24	Sack gardening is not an opportunity to eat biological products	−2	−1	−3
47 *	Youth are more willing to adopt this innovation	0	−2	−1
20 *	Households are not yet widely adopting sack gardening to address child malnutrition	−4	−2	−4
7	Sack gardening may not help households for nutritional benefit	−2	−3	−2
34 *	Women have less time to take care of their gardens because of other household tasks they perform	−3	−4	0
15 *	Sack gardening is more demanding in terms of works	−1	−5	−1

Note:  $p < 0.05$ ; asterisk (\*) indicates significance at  $p < 0.01$ .

### 3.3.3. Statements Distinguishing the Third Group

Sack gardening is significantly characterized by stakeholders in this group based on statements 5, 16, 27, 28, 44 (Table 4). These statements mention the time and distance women benefit from implementing sack gardening (5). These statements indicate that sack gardening reduces environmental pollution, avoids soil degradation, allows for easy control of gardening diseases, and avoids nutrient losses (17, 27, 24, 28, 40). The implementation also avoids water loss and prevents the presence of heavy metals in the final products (9, 16). These actors identify statements that converge towards a discourse that can be called: “the role of sack gardening in environmental protection”.

**Table 4.** Statements that differentiate stakeholders in Group 3 from those in Groups 1 and 2.

N°	Statements	F1	F2	F3
16 *	The usage of clean water is preferred in sack gardening production to avoid contamination, particularly by heavy metals, in vegetables	2	4	5
5 *	With sack gardening, women no longer have to do long distances to reach their gardens, that are now closer	3	2	5
27 *	Sack gardening can also help limit environmental pollution as it promotes the usage of biodegradable sacks	1	1	4
39 *	Sack gardening avoids soil-related constituents	1	0	4
36 *	All garden products can be used in sack gardening	0	0	2
9 *	Compared to ordinary gardening, sack gardening reduces water used from 3 to 2 times	1	0	2
48 *	The poor are more willing to adopt this innovation	3	4	1
44 *	Extension must do better to promote this innovation	3	3	1
40	Plants disease risks are limited in sack gardening	0	0	1
41 *	Extension services of sack gardening does not yet allow its scaling up	−2	−2	1
13	Vegetables from sack gardening may be harvested daily to respond to vegetable needs in households	1	2	0

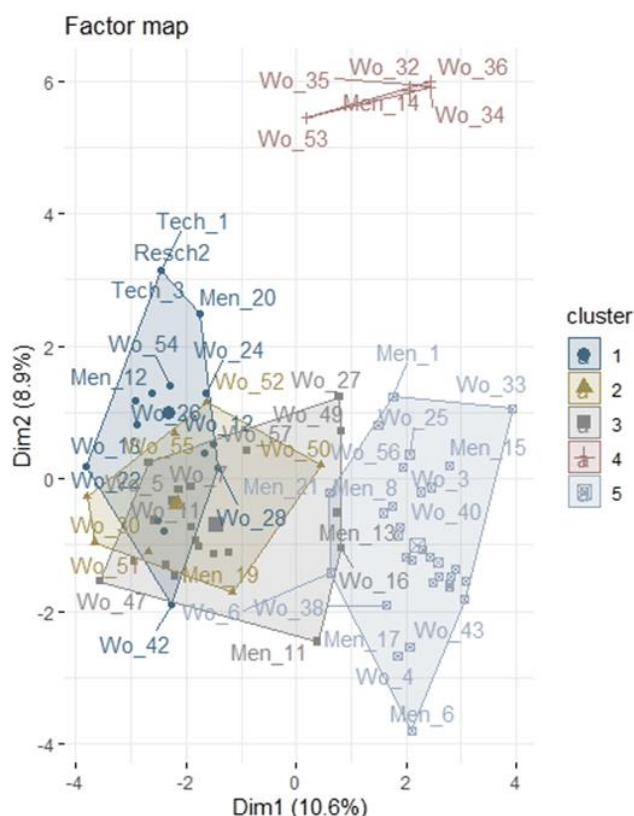
**Table 4.** Cont.

N°	Statements	F1	F2	F3
18 *	Sack gardening costs more than normal gardening	−3	−3	0
34 *	Women have less time to take care of their gardens because of other household tasks they perform	−3	−4	0
12 *	The problem of a balanced diet is somewhat solved with the diversity of vegetables sack gardening may offer	−4	−4	−1
32 *	Soil degradation can be avoided by practicing sack gardening	1	1	−1
43 *	Households that adopt this type of gardening do not benefit from it	−5	1	−1
24	Sack gardening is not an opportunity to eat biological products	−4	−4	−2
46 *	Men are more willing to adopt this innovation	−1	−1	−4
28 *	Soil degradation cannot be avoided even if the scaling up of sack gardening is done	−2	−1	−5
17 *	Sack gardening offers advantages to not clearing and weeding in technical itinerary of vegetable production	−1	5	−5

Note:  $p < 0.05$ ; asterisk (\*) indicates significance at  $p < 0.01$ .

### 3.4. Factors Establishment Using PCA in FactoMineR Package

Following PCA with FactoMineR and factoextra packages, five groups of stakeholders were identified (Figure 4). Table A2 shows the statements that were used to compose the discourses. The two axes conserve a variability of 19%. The first group of stakeholders was composed significantly of statements 2, 17, 19, 26, 27, 35. The second group was composed significantly of statements 1, 20, 25, 37, 45. The third group was composed significantly of statements 4, 6, 8, 17, 31, 42, 46. The fourth group was composed of statements 18, 9, 16, 34, 39, 5, 12, 27, 5.



**Figure 4.** Clusters of sack gardening stakeholders under package FactoMineR and factoextra packages.

## 4. Discussion

### 4.1. Methodology

The Q-method is a quantitative research tool used in stakeholder perception research. This method has no pretension for quantitative analysis for results extrapolation in the population. To ensure the relevancy of the results, it is Essential to validate the relevance of the sample statements. The methodology involved using key stakeholders to validate statements by using a proportional piling approach. The results of 60% in different groups for validating statements used in the Q-method showed stakeholder agreement regarding these statements.

The study was conducted within the framework of the Africa-RISING project in the regions of Bougouni and Koutiala in Mali, as described in the study area. In these two regions, the project has implemented test plots. New technologies, such as sack gardening, are implemented in these plots with the participation of producers in order to better impact beneficiaries through the technologies in the different Africa-RISING project villages and non-Africa-RISING project villages. The test plot approach adopted by the project is one of the best for sustainable production in rural communities. This approach allows for better extension of the implemented technologies, as stakeholders directly experiment with the technologies in plots before implementing them in households. Thus, the sampling to understand the perceptions regarding these technologies should take into account both communities that are directly concerned with the technologies and those that are not concerned [13]. Thus, one of the limitations of the present study could be the fact that the study focused only on Africa-RISING villages, due to budgetary limitations. The study would take into account the perceptions regarding sack gardening in non-Africa-RISING villages. However, this is not considered as a limitation as producers (women and men) from other villages were aware of these technologies and exchanged opinions with others. Moreover, access to test plots is not only reserved for producers from the African-RISING project. Other producers from non-Africa-RISING villages were also inspired by these technologies. Thus, the results of comparison between the perceptions of producers from Africa-RISING villages and producers from non-Africa-RISING villages would not be different from the current results. This comparison would be relevant if stakeholders in different villages do not exchange information, practices and perceptions. The focus group discussions implemented in the study limited this bias and were favorable to obtaining the holistic opinions of communities regarding sack gardening, rather than receiving only the individual perceptions of stakeholders. In the context of Mali, rural communities are linked by the way of thinking and they consider themselves as one large family, even if they are not in the same village. This comparison would be relevant if communities in these villages seek to differentiate themselves from others. This is not possible in the context of rural communities in Mali where a lot of things are exchanged.

Taking into account the diversification principle in sampling and especially to avoid the bias of representativeness of one group at the expense of another, both women and men were involved in the study. Women, however, were more numerous in the surveys. The sampling could limit the inference of the results regarding communities in these areas. Sack gardening is an activity promoted to support households through women that are more interested by this production method. So, women's opinions were more relevant. Furthermore, women are hardly listened to in surveys that concern households. On the other hand, the men interviewed also agreed to the idea that this production is more interesting to women, so that they would not have to spend a lot of money to pay for the vegetable needs of the household.

### 4.2. Social Characteristics

Through social characteristics, the majority of the communities practice gardening. These communities are young, do not have formal education and are generally married. We also noticed in the surveys that women were more represented. These show that household sack gardening is mostly practiced by women and the reason for engaging in

these technologies may be to respond to household needs and that sack gardening may support the household by providing vegetables for a balanced diet [14].

#### 4.3. Discourses

Through the factors from the Q-method analysis and from the PCA analysis by using the package FactoMineR in R, three factors were of most relevance. The first factor shows that sack gardening may support household food nutrition. The second factor supports the idea that sack gardening may respond to household needs in vegetable products and the last discourse supports the role of sack gardening in environment protection.

##### 4.3.1. First Discourse: “Sack Gardening for Reinforcing Household Food Nutrition”

In this discourse, the end-users were convinced of the role of nutritional support that the implementation of sack gardening may play. Sack gardening, according to this group, allows them to ensure a balanced diet, especially for their children. Indeed, the traditional household food is based on cereal (maize, rice, sorghum, millet). Thus, very few households have the means to consume garden produce. Garden produce is produced mainly in irrigated areas in the dry season. In these areas, these products are mainly designed for marketing and few households produce them for their own consumption. Sack gardening therefore appears to be a good bargain in terms of having gardening products all the time in households for their own consumption. With this production, the needs of children in minerals, some vitamins, even in vegetable protein, can be satisfied. This is also evidence that women perceive this production as one whose products may be used on daily dishes for household consumption. As shown by other studies, many cases of infant mortality in Africa are linked to malnutrition problems [15,16]. For these households, it is therefore an advantage to introduce sack gardening in order to limit the diseases related to nutritional deficiencies. For women, this gardening established in households allows them to prepare sauces without worrying about the costliness of garden produce. With this production, households have permanent access to vegetables to satisfy their nutritional needs, especially the vegetable product needs of their children.

##### 4.3.2. Second Discourses: “Sack Gardening to Respond to Household Needs for Quality Vegetables”

This discourse supports the statement that sack gardening is not only designed for commercialization, but may also respond to the vegetable needs of households. In this discourse, women are convinced that sack gardening may respond properly to their vegetable needs. In the past, the authors of refs. [17,18] indicated that households in rural areas and often in large African cities often could not afford to consume the vegetables of their choice, especially during the dry season period, because these products were very expensive for consumers. With sack gardening, women, mainly considered as providing good meals, can easily access and afford these products. The adoption of this technology would also avoid certain daily expenses for households. The present discourse also shows that good quality produce may be obtained from sack gardening. For the authors of [19,20] that justified the relevancy of home consumption through the production of most of the food we consume, sack gardening could allow households to have easy access to healthy and safe products. Moreover, the results show that households practice sack gardening mainly for home consumption and not for commercialization. This discourse is also a response to the problems met in certain areas of agricultural intensification in Africa, and particularly in Mali. In the Sikasso region of Mali, the number of children suffering from malnutrition is higher than in other regions of the country. Two main reasons may explain this situation. Producers in this region prefer physical cash at the expense of consuming healthy and nutritious food. The population also has little knowledge of the importance of a balanced diet. Even if households seek to produce for cash, they may use a part of their land to produce vegetables for their own consumption. Sack gardening thus appears to be a solution for a balanced diet as mentioned by stakeholders in the first discourse. It was

also mentioned that sack gardening could help women who do not have access to land for agricultural production. In fact, in ref. [21], they also indicated that women have difficulty in accessing land in areas where production is more designed for cash crops.

#### 4.3.3. Third Discourses: “Role of Sack Gardening in Protecting the Environment”

Factor 3 or discourse 3 emphasizes the role sack gardening plays in protecting the environment. The technology uses compost or organic manure as the growing medium to produce vegetables. Using organic manure improves soil quality, reduces soil degradation and avoids nutrient loss. Another advantage of this form of production is that sack gardening limits the presence of heavy metals in vegetables. Indeed, studies in the past showed that vegetables and other food products contain heavy metals. This reflects the fact that vegetables are more often produced along the roadside, are more exposed to vehicle emissions, and therefore to carbon monoxide [22]. The implementation of sack gardening for household consumption may avoid the presence of these heavy metals in vegetables and reduce water wastage [23]. These advantages justify the high rate of the adoption of the technology by households. On the other hand, this type of vegetable production on a small scale may allow them to better control vegetable diseases, because without sacks, soils are more exposed to parasites and to pathogenic germs. This type of production would thus allow them to have healthier and safer products than in the case of ordinary gardening, where the soils are exposed. Another advantage, which can be discussed, is that sack gardening allows women to save time for other household activities. However, if there is no space in the household for this type of production, the problem of distance would remain.

#### 4.4. Practical Implications

In view of the results, some practical implications arise to better support the adoption of sack gardening in households, given the nutritional role that this production could play. These implications are at three levels: household, technicians and researchers, and policy.

##### 4.4.1. Household Level

At household level, the results should be reported with particular emphasis on the supportive nutritional role that sack gardening can play, especially in improving the nutritional quality of household meals. In the long run, its scaling up in households could protect children from malnutrition. Households could better protect the environment and ensure the availability of quality produce that sack gardening can offer [24]. The practice of sack gardening, over time, could help improve soil composition by adding organic matter used in the sacks. Indeed, the composition of soils is deteriorating more and more with the phenomenon of global warming [9,25]. The scaling up of this production would therefore be beneficial to soil reconstitution. This would be beneficial for plant growth. In another sense, it could also help households address the problem of lack of means to purchase vegetables, as households have limited means to purchase vegetables for consumption. At the village level, a common space could be given to households for gardening to improve vegetable consumption. Farmers’ organizations could further support this production in a reinforcement capacity to their members of the advantages of consuming vegetables, the advantages of sack gardening and especially on the different vegetables that can be easily grown in a sack garden for consumption. Regarding the benefits provided for the environment and for the well-being of households, sack gardening needs to be more widely promoted in rural areas, especially where children suffer from malnutrition. In the future, funding to support good household nutrition could allow this technology to be implemented in other villages where people have not yet received the technology. However, the other challenge to scaling up sack gardening may be the unwillingness of men in households to financially support women in purchasing vegetables or other useful condiments for household meals. Feedback should emphasize the different perceptions of people about sack gardening. It was explained that none of the producer groups rejected

this production and that all groups perceived sack gardening as an opportunity that could improve their living conditions.

#### 4.4.2. Technical and Research Level

Research and development should work for the development of populations and especially to allow these populations to ensure their nutritional and food security [23]. In this vision, sack gardening would be increasingly used as a springboard. Indeed, the extension and research through this production in rural areas could better achieve their objectives as gardening as a strategic production for Mali. To better promote the extension of this technology, technicians will have to accompany producers, especially women producers in order to support household needs in vegetables. Assistance will also be oriented in helping producers to identify constraints that are detrimental to production. A cost-benefit analysis with an explanation of the sack garden advantages for the household's nutrition could help convince producers who are still hesitant to practice the technology. Indeed, increasing the rate of adoption of sack gardening suggests a relevant role that technicians and researchers should play. Research should work to better understand gardening products that are available, acceptable and used daily in households. Then, the extent in which production may be achieved in sack gardening conditions could be simplified. This would increase users' confidence to experiment with the technology. In practice, users find that production equipment is expensive, especially the pipeline and bags used. Research could implement innovation in order to reduce production costs. Extension services and researchers, by indicating the quality of organic matter and water used, will protect households against diseases from heavy metals, for instance. In sum, the success of this production depends on the roles of technicians and research, although it counts on means being mobilized by policy.

#### 4.4.3. Policy Level

The future of sack gardening depends not only on the households that adopt the technology, the technicians and researchers who innovate the technology, but also on political decisions which must continue to provide the means for its implementation in rural areas. As mentioned above, garden production is a strategic production for Mali. Then, policy support for garden production is of particular importance. The results of this study showed the willingness of women to adopt this production as a response to provide nutritional security for their children and for all their families. Indeed, policies can invest in sack gardening, which can enable women to respond to the household's nutritional needs [26].

### 5. Conclusions

The outcome of this study allowed us to understand the role sack gardening may play in farm households in southern Mali. In general, we noted that households' perceptions or opinions of sack gardening were mostly geared towards its contribution to household vegetable needs, nutritional and health benefits to children and environment protection. The technology is practiced by women for their household nutritional needs. The study allowed for a better understanding of the discourses held by different stakeholders around sack gardening. For stakeholders, sack gardening may help households to have balanced diets, provide availability of high-quality vegetables and protect the environment. This type of gardening also allows households to have healthier vegetables, unlike vegetables sold in open areas, whose origins may be questionable or vegetables produced on the road side, exposed to vehicle exhaust fumes. Sack gardening, therefore, appears to be a solution for households to limit the issues of poor nutrition in their children in the region. Its promotion would therefore be beneficial. However, for a better scaling up of the technology, technicians, researchers and politicians have a role to play in order to improve household food and nutritional security. This study can be complemented with a quantitative study to better scale up the technology. For instance, other analyses may be carried out to

understand the willingness to pay (WTP) for vegetables from sack gardening or studies can be conducted to compare their nutritional qualities with conventional methods of vegetable production to better inform scholars and policy makers in decision making in order to support food insecurity alleviation. Restitution of results in rural areas, complementary studies on the quality of product from sack gardening and cost–benefit analyses of this production may increase the adoption rate of the technology.

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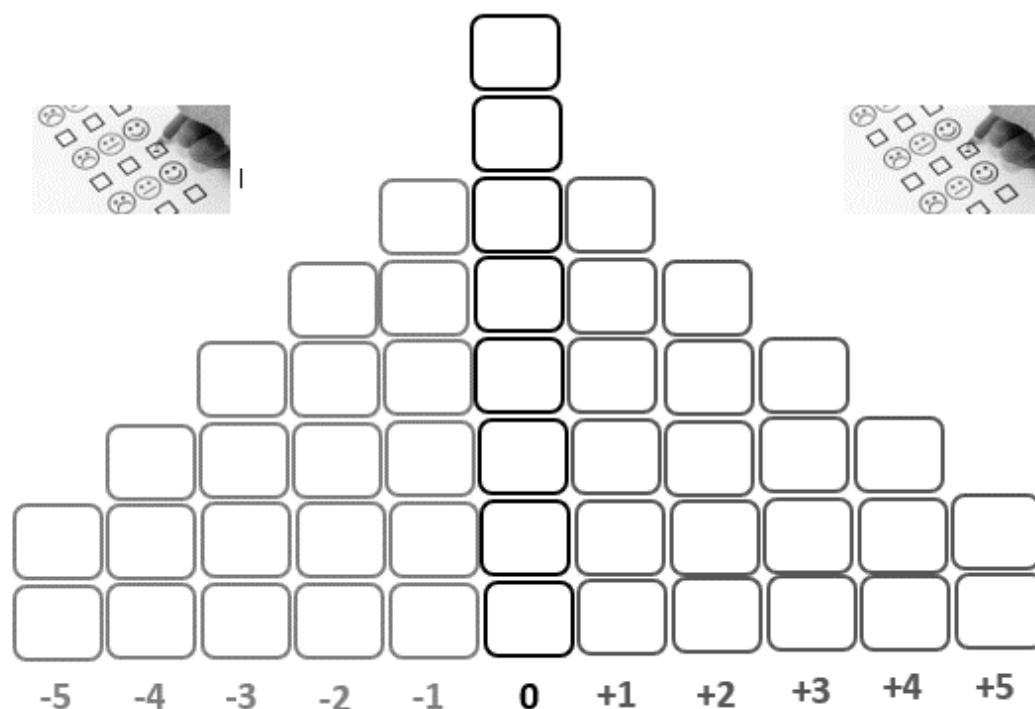
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## Appendix A



**Figure A1.** Card ranking by different interviewees (Source: from data collection, 2021).



**Figure A2.** The ranking grid used in the Q-method.

**Table A1.** Statements identified in the focus group discussions to constitute the Q-set.

N°	Statements	Score (%)
1	Sack gardening is a technology developed to address the problem of malnutrition in households	80
2	Sack gardening has a foreign origin that does not take into account gardeners' realities in Mali	65
3	Sack gardening helps households to better ensure availability of vegetable products	61
4	With sack gardening, women may better take care of their gardens because of its proximity	65
5	With sack gardening, women no longer have to walk long distances to reach their gardens, that are now closer	81
6	Sack gardening cannot help poor people to have vegetables daily	75
7	Sack gardening may not help households for nutritional benefit	70
8	Water economy is one of the benefits of sack gardening	65
9	Compared to ordinary gardening, sack gardening reduces water use from 3 to 2 times	65
10	Compared to ordinary gardening, sack gardening reduces water use from 2 to 1 time	62
11	Compared to ordinary gardening sack gardening does not reduce water used	66.5
12	The problem of balanced diet is somewhat solved with the diversity of vegetables sack gardening may offer	60
13	Vegetables from sack gardening may be harvested daily to respond to vegetable needs in households	61.5
14	Vegetables from sack gardening may not be used frequently to respond to household needs	75
15	Sack gardening is more demanding in terms of work	70
16	The usage of clean water is preferred in sack gardening production to avoid contamination, particularly heavy metals, in vegetables	70.5



Table A1. Cont.

N°	Statements	Score (%)
17	Sack gardening offers advantages of no clearing and weeding in the technical itinerary of vegetable production	65.5
18	Sack gardening is more expensive than normal gardening	75
19	Sack gardening produce is of better quality	71
20	Households are not yet widely adopting sack gardening to address childhood malnutrition	72.5
21	Sack gardening may help households to respond positively to a nutritional deficit in children	70
22	Sack gardening, if implemented in households, may contribute to nutritional security	65
23	Sack gardening does not appear to be advantageous for women to respond to the nutritional needs of households.	65
24	Sack gardening is not an opportunity to eat biological products	68
25	With sack gardening, households can be less dependent on the price volatility of vegetable products	60
26	In Africa, sack gardening may contribute to better protection of the soil as it does not require soil work	78
27	Sack gardening can also help limit environmental pollution as it promotes the usage of biodegradable sacks	76
28	Soil degradation cannot be avoided even if sack gardening is scaled up	75
29	The practice of sack gardening is more difficult for women	60
30	Sack gardening is not suitable for all vegetable production	65
31	Sack gardening is well suited for household consumption and not for commercialization purposes	75
32	Soil degradation can be avoided by practicing sack gardening	62
33	The land lack issue met by women is no longer an issue with sack gardening	72
34	Women have less time to take care of their gardens because of other household tasks they perform	62
35	Sack gardening can never constitute a warranty to consume vegetables for households	61
36	All garden products can be used in sack gardening	80
37	The usage period of sack gardening is too short to pay attention to	65
38	With this close-proximity production, households may better feed children without hard work	75
39	Sack gardening avoids soil-related constituents	66
40	Plant diseases risks are limited in sack gardening	60.5
41	Extension services of sack gardening have not yet allowed its scaling up	75
42	As it is a new innovation, sack gardening is not yet widely adopted	70
43	Households that adopt this type of gardening do not benefit from it	80
44	Extension must do better to promote this innovation	86
45	Women are more willing to adopt this innovation	80
46	Men are more willing to adopt this innovation	75
47	The youth are more willing to adopt this innovation	76
48	The poor are more willing to adopt this innovation	75.5

**Table A2.** Means in category of statements to compose discourse according to ACP function in package FactoMineR.

Factor 1			Factor 2			Factor 3			Factor 4		
Statements	Mean in Category	Overall Mean	Statements	Mean in Category	Overall Mean	Statements	Mean in Category	Overall Mean	Statements	Mean in Category	Overall Mean
17	3.6 ± 1.5 ***	0.46 ± 2	25	2.5 ± 2.0 ***	0.2 ± 1.1	31	2.7 ± 1.8 ***	1.0 ± 1.8	18	0.6 ± 0.7 ***	-2.6 ± 1.7
27	4.1 ± 1.1 ***	1.8 ± 1.3	45	4.6 ± 0.5 ***	3.2 ± 1.2	42	0.4 ± 1.7 ***	-1.0 ± 2.2	9	2.3 ± 0.7 ***	0.5 ± 1.0
2	-0.1 ± 0.9 **	1.1 ± 1.4	20	-0.7 ± 1.6 **	-2.7 ± 1.8	46	-0.6 ± 0.8 **	-1.3 ± 1.3	16	5.0 ± 0.1 ***	2.5 ± 1.4
35	-0.6 ± 2.3 **	-1.8 ± 1.7	37	-0.7 ± 1.7 **	-2.2 ± 1.4	8	2.8 ± 1.5 **	2.1 ± 1.3	34	-0.2 ± 0.3 ***	-2.6 ± 1.5
42	0.4 ± 1.8 **	-1.0 ± 2.2	28	0.1 ± 1.8 **	-1.6 ± 1.8	6	-1.8 ± 1.9 **	-2.8 ± 1.8	39	3.3 ± 1.4 ***	1.3 ± 1.4
7	-1.4 ± 1.45 *	-2.3 ± 1.6	41	0.2 ± 1.7 **	-1.2 ± 11.6	17	2.0 ± 2.2 **	0.5 ± 2.9	5	4.7 ± 0.5 ***	2.6 ± 1.5
14	-0.7 ± 0.97 *	-1.41 ± 1.7	43	-1.4 ± 3.8 *	-2.8 ± 1.8	4	2.5 ± 1.2 **	1.9 ± 1.1	12	-0.5 ± 1.1 **	-2.5 ± 1.6
24	-1.0 ± 1.06 *	1.8 ± 1.6	13	3.2 ± 1.4 *	1.9 ± 1.7	13	2.7 ± 1.5 *	1.8 ± 1.7	27	3.5 ± 1.1 **	1.8 ± 1.3
30	-2.0 ± 1.06 *	-1.45 ± 1.8	40	1.0 ± 1.1 *	0.1 ± 1.2	45	2.7 ± 1.2 *	3.2 ± 1.2	41	0.7 ± 0.8 **	-1.3 ± 1.6
12	-3.3 ± 0.9 *	-2.5 ± 1.6	32	-0.2 ± 0.8 *	0.9 ± 1.5	27	1.2 ± 1.0 *	1.7 ± 1.3	7	-1.0 ± 2.2 *	-2.3 ± 1.6
22	2.4 ± 1.4 *	3.1 ± 1.4	44	1.5 ± 1.2 *	2.5 ± 1.3	39	0.7 ± 1.3 *	1.3 ± 1.4	3	0.1 ± 0.2 *	1.5 ± 1.6
19	1.1 ± 0.5 **	1.9 ± 1.1	1	1.2 ± 1.4 ***	3.2 ± 1.5	40	-0.5 ± 1.3 *	0.1 ± 1.2	44	1.2 ± 0.4 *	2.5 ± 1.3
26	-0.2 ± 0.5 **	0.9 ± 1.5	25	2.5 ± 2.0 ***	0.2 ± 1.1	26	1.1 ± 1.2	1.0 ± 1.5	13	0.1 ± 0.2 *	1.8 ± 1.7

\*  $p$  value < 0.05; \*\*  $p$  value < 0.01; \*\*\*  $p$  value < 0.001.

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