Fikadu and Gebre *Agric & Food Secur* (2021) 10:24
https://doi.org/10.1186/s40066-021-00299-5

Agriculture & Food Security

RESEARCH

Open Access

Evidence from Fogera district in Ethiopia on configuration of farmer's information literacy conditions that explain better productivity performance of the horticultural crops

Asmiro Abeje Fikadu[1*] and Girma Gezimu Gebre[2]

Abstract

Background: The combinational/configurational effects of the agricultural information literacy indicators are believed to have an influence on the productivity performance of the horticultural crops. Previous studies have emphasized the contributions of the net-effect of each information literacy condition of smallholder farmers on the productivity performance of the horticultural crops. Yet, these studies failed to make qualitative analysis on configurational effects of the agricultural information literacy conditions.

Methods: The study addresses the qualitative questions that are outside the scope of the conventional variable-oriented method. It aims to disentangle the causal complexity that links with productivity performance in Fogera district of the Amhara region, Ethiopia. A fuzzy-set qualitative comparative analysis (fsQCA) of 80 smallholder farmers was conducted through a simple ransom sampling technique from two kebeles of Fogera district to examine the combinational effects of agricultural information literacy condition on the productivity performance instead of individual net-effect.

Results: The results of the fsQCA model indicated that a combination of two or three conditions include the high levels of farm organizational, farm record-keeping, and farming skills to be consistently sufficient to attain high productivity performance of horticultural crops. These configurations help to seek relevant policy information and make policy strategies on the horticultural sector to improve its productivity performance.

Conclusion: Thus, improving the joint information literacy effects of the farmers regarding their organizational, farm recording, and farming skills should give due attention by governmental and non-governmental organizations that work to improve the productivity performance of the horticultural crops.

Keywords: Configurational effect, FsQCA, Information literacy, Necessity, Productivity performance, Sufficiency

Background

Agriculture plays a significant role in the economic growth of many countries in the world [1]. For instance, in 2017, it contributes about 35.8% of gross domestic product (GDP) and 70% of employment opportunities in Ethiopia [2, 37]. Hence, agricultural sector is considered an engine for overall economic growth of Ethiopia. Despite of such economic importance, the agricultural sector in Ethiopia is underdeveloped. About 98% of the farmers are smallholders who engaged in subsistence agriculture [6], while the rest 2% are large-scale

*Correspondence: asmiro2013@gmail.com
[1] Department of Agricultural Economics, Debre Tabor University, Debra Tabor, Ethiopia
Full list of author information is available at the end of the article

commercial producers who engaged particularly in seed production in the country [26].

On the other hand, rapid population growth in Ethiopia raises the level of food consumption. This requires more food production to meet the mounting demand and ensure food security. Increasing the level of food production may involve more extensive and intensive use of agricultural information, land, labor, fertilizer, water, and other agricultural inputs. It also requires designing and implementing sound agricultural policies, strengthening rural institutions, and promoting agricultural research. Accordingly, the Ethiopian government has made massive efforts to increase horticultural crop yield since 2010 [23]. This is because horticulture sector plays a significant role in job creation, income generation, improving nutritional status, poverty alleviation, and closing gender gaps in the country. It helps to maintain an ecological balance since its diverse species across locations [15].

The nexuses between agricultural information and agricultural productivity in Ethiopia and in the global context

Agricultural information literacy has been explained as a set of skills and competencies for identifying, accessing and using agricultural information to improve agricultural productivity [22]. Agricultural information provisions through education have larger impacts on agricultural productivity in the existence of fast technical change. Because knowledge and skills acquired through education helps farmers to regulate more readily to the new opportunities provided by technological innovations [17]. A study by [39], which focuses on agricultural information literacy, noted that farmers lack skills in identifying the sources of agricultural information according to their preferences. They found a positive relationship between access to agricultural information and agricultural productivity in the Chongqing province of China. An analysis by [4] witnessed that agricultural information through telephone is a significant contributor to growth in agricultural production in Africa. As found by [30], the information that receive from extension agents help smallholder farmers to improve their skills in farming, organizational, and farm record-keeping. This, in turn, could improve the productivity performance of their horticultural crops.

Hence, the productivity performance of horticultural crops' for smallholder farmers would enhance through making an investment in farmers' agricultural information literacy. Agricultural information and its access enable participants in the farming system to make informed and right decisions towards increasing agricultural productivity [21].

The main sources of agricultural information for farmers in Ethiopia are governmental and non-governmental extension service providers. Despite the existence of those sources of agricultural information, a small proportion of smallholder farmers are accessing and utilizing it. The reason might be due to poor extension service delivery system in the country [6]. The insufficient access to agricultural information is one of the causes for low agricultural production, food insecurity, and poor livelihoods in Ethiopia [6]. Thus, extension agents are expected to ensure that the smallholder farmers can identify, access, and use the information on modern farming methods (uses of improved crop varieties, improved agronomic packages, and so on) to improve production and productivity of horticultural crops. The farmers' means of accessing of this information might be radio, television, mobile free short messaging services, farmer's field visit, workshops and training. The study by [12] in Bangladesh showed that the local radio is extensively used for the dissemination of technical information on good farming practices, weather forecast, and crop market prices in the local languages. This applies for the agricultural sector in Ethiopia too. This would be an important issue for agricultural information literacy, which is directly related to critical thinking skills and emphasizes various activities like selection, evaluation, rejection, topic definition, organization, and question definition [5].

In 2017/18, about 26% of smallholder households were involved in horticultural crop production in the Amhara region of Ethiopia [3]. In the same year, about 24% of crop land was allocated for horticultural crop production in the region [8].

Moreover, the productivity performances of the horticultural crops in the region have been affected by not only the "net-effect" of each potential factor but also influenced by the configurational or combinational effects of two or more factors [28]. Combinations of the agricultural information literacy indicators are believed to have an influence on the productivity performances of the horticultural crops [30]. Previous studies found that the individual net-effect of agricultural information conditions, such as education ICT, and extension provision enhance agriculture production [4, 33, 36]. None of these studies examined the combinational effects of two or more factors on the productivity performance of the horticultural crops. Moreover, they were not from the Fogera district in Ethiopia. Hence, the current study is to investigate the configurational effects of the agricultural information literacy indicators on the productivity performance of the horticultural crops in Ethiopia in general and in Fogera district in particular. Therefore, the objective of this study is to examine the configurational effects of agricultural information literacy conditions that would explain the productivity performance of horticultural crops in the Fogera district of the Amhara region, Ethiopia.

Research methods

Description of the study area

Fogera district is located in South Gondar zone of the Amhara regional state in Ethiopia (Fig. 1). The district lies between 110 58 N latitude and 370 41 E longitude [7]. The total land area of the district is 117,414 ha. The altitude of the district ranges from 1774 m above sea level (m.a.s.l) to 2410 m.a.s.l, allowing a favorable opportunity for wider crop production and better livestock rearing [7]. The average size of landholding in the district is 1.4 ha with minimum and maximum size of 0.5 and 3.0 ha, respectively [13, 14], while the typical small farm size in Ethiopia is 0.9 ha at national level [29].

Model specification

The study applied a fuzzy-set Qualitative Comparative Analysis (fsQCA) approach to assess the configurational effects of four micro-level farmers' agricultural information literacy conditions (formal education level, farm organizing skill, farm record-keeping skill, and farming skill). Using the fsQCA approach enables study to explore more theoretical possibilities. The fsQCA helps to select cases for comparison that assumes homogeneity of cases and provide more degrees of freedom which are not allowable in the quantitative analysis approach or variable-oriented analysis [19]. The fsQCA is a mixed-method that able to combine the quantitative empirical testing [20] and qualitative inductive reasoning made by the implementation of case analysis [27]. Moreover, fsQCA handles logical complexity acknowledging that different results can be produced by alternative combinations of characteristics when appropriately combined with other conditions [16]. On the other hand, the quantitative analysis approach has limited capacity to engage directly

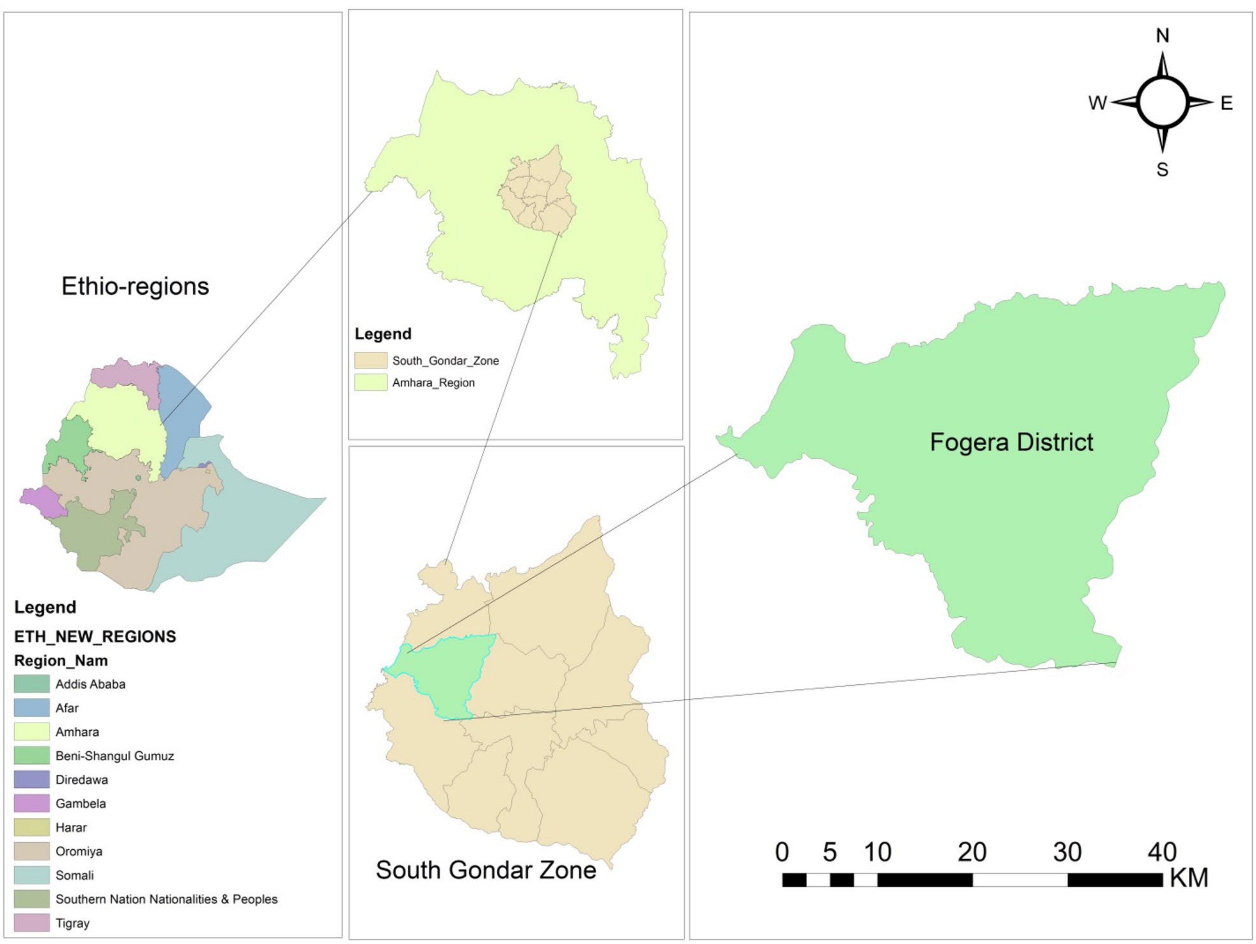

Fig. 1 The map of the study area. Source: authors [2020]

with theoretical discourse with data analysis. It relies on measurable empirical data, and diminishes the possibility of diverse interpretation and too much complexity. Moreover, quantitative analysis approach cannot capture the set-theoretic nature in most of the verbal statements drawn from the theories [19].

Hence, the fsQCA approach helps to identify the multiple pathways to success, uses as a bridge implementation and impact findings to explore factors associated with outcome variables, emphasizes the need for designing policy, and actions on the enhancement of horticultural crops' productivity, profitability and product quality. The fsQCA approach enabled us to deal with the causal complexity [28] and it assisted the evaluation of cases as configurations of causal conditions rather than the "net-effect" of each indicator on the outcome variables. We were able to conduct context-specific assessments showing the ways in which multiple causal conditions linked to a specific outcome, such as productivity, profitability, and product quality. Moreover, the fsQCA method helps for this study because of its compatibility with micro-level data analysis in small or medium sample size [24] and [27]. The fsQCA approach has been applied to examine the complexity of the causal relations in different sectors. For instance, [10] applied the fsQCA approach map to develop policy strategies for the optimization of municipal waste management in Italy [18] applied it to investigate public perception, readiness and supportiveness of energy transition towards a circular bio-economy in Greece. Moreover, [34] applied the fsQCA approach to examine multiple perspectives of the resilience engagement in Northern Ireland while [24] used it to investigate tourism and refugee crisis in Greece, [31] applied the fsQCA approach to examine standards of good practice; [25] used it to analyze the structural conditions of the health in 131 countries in the world.

As illustrated in [9, 27, 28], various questions can be answered through the fsQCA method that could not be addressed through the quantitative data analysis. Thus, using the fsQCA approach, this paper answers a question on what combination of farmers' agricultural information literacy conditions is consistently sufficient for high productivity, high profitability, and high product quality of the horticultural crops.

We adopted the operational framework developed by [10] to answer the above research question. Accordingly, our operational framework has been built-in three main procedures (Fig. 2). These are: (1) the identification of the information literacy and productivity performance variables; (2) the identification of the causal relations between these variables, and (3) analysis. The first two procedures deal with data collection through questionnaire, Focus Group Discussions (FGD), and Key Informant Interview (KII). Then, the relevant system variables were derived. The detail illustration of each procedures of the operational framework of the study is discussed as follows:

1. Identification of the variables: this procedure was implemented by means of a data triangulation approach that added soundness to our results [10, 11]. We first accompanied face-to-face individual interview with the horticulture farmers. Then, we

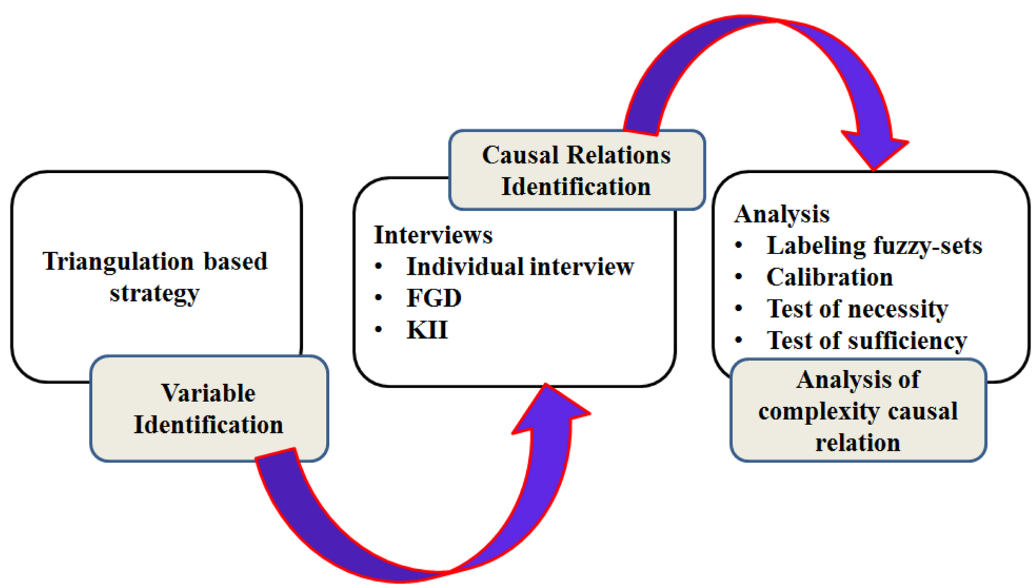

Fig. 2 Operational framework of the study. Source: authors modification based on [10]

validate the collected information through FGD and KII as well as we tried to integrate this information with the scientific data that were collected from literature. The variables were derived to make fsQCA analysis. An innovation platform of the stakeholders were organized and active discussions held to reach a consensus regarding the relevant variables.

2. Identification of causal relations: the attitude and knowledge of the sample farmers were used to define fuzzy-set of the productivity performance of the horticulture farming. Thus, a system is composed of three outcome variables and four causal or condition variables with a three-degree scale (i.e., high, medium, and low) (Fig. 2). The characteristics of each variable were described in the "Data and measurements" section.
3. Analysis of a complexity causal relation: after attaining the fsQCA approach using the farmers and key informant interview, analysis of a complexity causal relation has conducted in four steps; these are, identification and leveling of the fuzzy-sets, calibration, test of necessity, and finally conducted test of sufficiency (Fig. 2). The detail explanation of each steps of the analysis was described in the "Analysis strategy" section.

Data and measurements

The productivity performance of the horticultural crops and farmers' agricultural information literacy conditions have been defined and evaluated qualitatively by the sampled smallholder farmers based on their perception and preference. We selected two kebeles in the district through purposive sampling technique due to their high potential of the horticulture production. A total of 400 farmers were engaged in horticulture production in selected kebeles. These farmers are homogenous in terms of farming system, livelihood strategy, institutional, and socio-cultural setups. Even though the number of the horticulture farmers in the sample kebeles is small, there is high potential for horticulture production. Yamane [38] formula was employed to determine the sample size from the total horticulture farmers in the selected kebeles. This is because the population size of the target group is known. The sample size was calculated at the 10% precision level (e). Accordingly, 80 smallholder horticulture (onion, potato, garlic, and tomato) producers were included in the study using a simple random sampling technique. The formula is given as:

$$\mathrm{n} = \frac{\mathrm{N}}{1 + \mathrm{N(e)}^2} = \frac{400}{1 + 400(0.1)^2} = 80,$$

where n = sample size, N = population size, e = level of precision or the error in which the researchers tolerated which is 10%.

Outcome variables

The target outcome variable in this study was the smallholder farmers' productivity performance of the horticultural crops. Following [30], the productivity performance of the horticultural crops, in this study, has been measured in terms of productivity, profitability, and product quality. The details of the specification of the outcome variables are explained using ordinal scale, such as 1 = low; 2 = medium; and 3 = high).

1. Productivity: the general measurement of productivity is output per unit of land. However, in the context of this study, this outcome variable has been measured through a self-assessment of the respondents using an ordinal scale measurement (1 to 3; low, medium, and high, respectively).
2. Profitability: the general measurement of the profitability is gross margins per unit of land. But, in the context of this study, this outcome variable has been measured through a self-assessment of the respondents using an ordinal scale measurement (1 to 3; low, medium, and high, respectively).
3. Product quality: the product quality can be measured based on the ability of the horticultural produce to meet the consumers' expectations like shape, taste, shelf live, variety, and color. Nevertheless, in the context of this study, this outcome variable has been measured through a self-assessment of the respondents using an ordinal scale measurement (1 to 3; low, medium, and high, respectively).

Conditions/indicator/independent variables

The possible causal conditions or indicator variables are farmers' agricultural information literacy that has been measured in terms of formal education level, organizational skill, farm record-keeping or farm accounting skills, and farming skill. Sang and Cheruiyot employed these causal factors for measuring the horticultural information literacy in Kenya [30]. The detailed specification of the causal conditions or indicator variables is explained below:

1. Level of formal education: indicates the years of schooling for the respondents. But, the respondents measured it in terms of ordinal scale, thus, this indicator can be measured in terms of ordinal scale of 1 to 3, which represents low (maybe 1–4 schooling), medium (5–10 schooling), and high (> 11 schooling).

2. Organizational skills: indicates the ability to use farm resources available in an effective way. It is defined as making priority of the activities throughout the farming process. This indicator is measured in terms of ordinal scale of 1 to 3, which represents low, medium, and high, respectively.
3. Farm record-keeping/farm accounting skills: is defined as the practice of keeping documents on production inputs and outputs of the horticulture farming. This indicator can be measured in terms of ordinal scale of 1 to 3, which represents low, medium, and high, respectively.
4. Farming skills: is explained as the ability to carry out the horticultural farm practices well that means, it indicates the farmers to enable efficient horticulture farming. This indicator is also measured in terms of ordinal scale of 1 to 3, which represents low, medium, and high, respectively.

Analysis strategy

We followed four stages to address our objective through the fsQCA approach:

Stage 1: the definition and labeling of the fuzzy-sets

The key step in the fsQCA approach is the construction and standardization or calibration of the fuzzy-sets. The first stage in fsQCA, after data collection, is to construct the variables to be used in the analysis. Hence, we developed a "membership function" that maps each condition or outcome variable into the unit interval [0–1]. Actually, the success of any fuzzy-set analysis is determined by this step [28]. As denoted by [28, 31, 32], we defined two fuzzy-sets due to the asymmetry in the set-theoretic analysis. First, the smallholder farmers who have high productivity, high profitability, and high product quality of horticultural crops were one categorized fuzzy-set. Second, the smallholder farmers who have low productivity, profitability and product quality of horticultural crops were another fuzzy-set. For each condition, hence, a fuzzy-set was constructed and the degree of the membership of each case in the constructed fuzzy-sets was determined. As a result, the fuzzy-set membership scores ranged between 0 and 1, which indicated whether the cases had a low or high level of each condition [25] and [27].

Stage 2: calibration

As described by [28], we used a direct method of data calibration to convert our interval-scale measures. In the direct calibration method, specifying three qualitative anchors that structure a fuzzy-set is the vital task [28], such as the threshold for full membership, the threshold for full non-membership, and the threshold for the crossover point or maximum ambiguity point. The specified of these three thresholds must be defined based on the practical and theoretical knowledge of the cases [28].This stage determines the range of meaningful variation in the features and what values correspond to varying levels of membership in the set of cases with that feature through substantive knowledge of the cases.

Stage 3: test of necessity

After the variable calibrated and transformed into measures of fuzzy-set membership, the next step is to identify conditions characteristics that have a necessary relationship with the outcome variables. Necessity can be defined as when the causes must be present to yield the outcome, but the existence of the cause does not always ensure the outcome's presence. Ragin argued this type of asymmetrical association as the outcome is the subset of the causes. This helps us to identify key variables and their combinations by reducing the number of conditions in the next step of the analysis [27] and [28]. Thus, based on set-theoretic relationships, if the fuzzy-set scores of a condition or configuration are consistently equal to or higher than the fuzzy-set scores for the outcome variables, a relation of necessity is indicated, which means a causal condition is necessary for an outcome when instances of the outcome variables constitute a subset of instances of the causal condition [28]. As illustrated in Fig. 3, the set of the productivity performance of the horticultural crops would be the subset of information literacy indicators; here, if you want to remove the causes (X), then you cannot have the outcome (Y).

Stage 4: test of sufficiency

Sufficiency is defined as when the cause or predictor variables can produce the outcome variable or productivity performance, but the outcome can be produced by other causes (other predictor variables). Ragin argued this type of asymmetrical association as the causes are the subset of the outcome [27] and [28]. If the fuzzy-set scores of a condition or configuration are consistently equal to or smaller than their fuzzy-set membership scores on the outcome variables, this means that the configuration or condition is a fuzzy subset of the outcome; hence, this set relationship suggests that the condition is sufficient for the outcome [28].

As illustrated in Fig. 3, the set of the information literacy indicators would be the subset of the productivity performance of the horticultural crops; here, if you want to remove the causes (X), then you will still have the outcome (Y) because there are other different causes that affect the productivity performance of the horticultural crops.

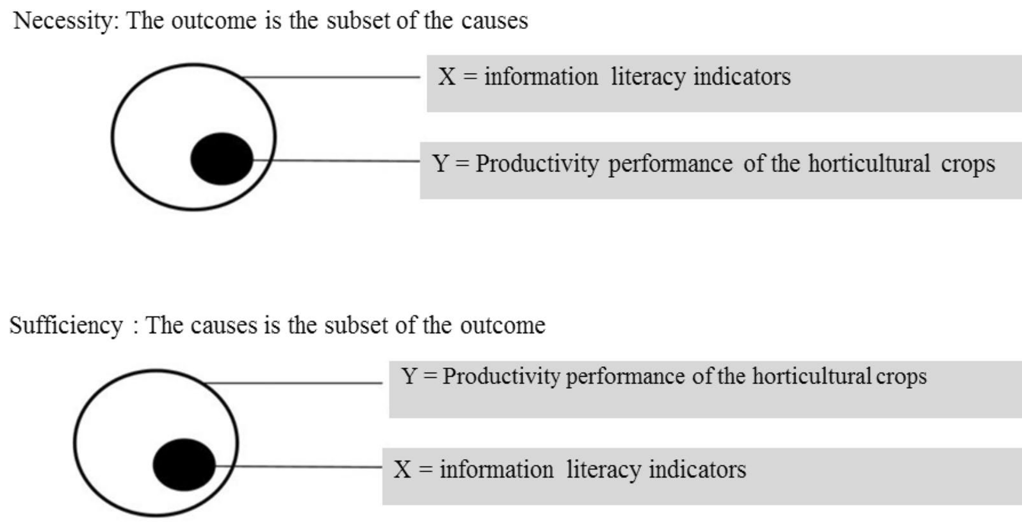

Fig. 3 A graphical illustration of necessity and sufficiency in fsQCA approach. Source: own manipulation based on [28]

The truth table formalizes and elaborates one of the key analytic strategies of comparative research that examining cases sharing specific combinations of causal conditions to see if they share the same outcome [28].

Consistency is the degree to which the data support the set theoretical privilege supported by the researcher (i.e., necessity or sufficiency). Consistency scores range from 0–1, where 0 indicates that the causal combination is not a subset of the outcome and 1 indicates that the causal recipe is a perfect subset of the outcome. In set theory, consistency of a sub-relation with fuzzy measures emerges when the membership scores in a specific attribution causal set are equal or systematically less than the membership scores in the outcome set [28, 35]. Hence, consistency can be calculated as follows:

$$\text{Consistency}(X_i \leq Y_i) = \frac{\sum_i[\min(X_i; Y_i)]}{\sum_i (X_i)},$$

where i is the horticulture farmer; X_i is the membership score in the X configuration; and Y_i is the membership score in the outcome condition.

Coverage denotes the proportion of cases that shows the outcome that the causal conditions explain. In principle, coverage is conceptually similar, but not mathematically equivalent to a measure of statistical effect size (e.g., "total variance explained"). Coverage includes the assessment of sufficient configurations' empirical importance [28, 35]. Thus, the mathematical nation for the coverage is calculated as follows:

$$\text{Coverage}(X_i \leq Y_i) = \frac{\sum_i[\min(X_i; Y_i)]}{\sum_i (Y_i)}.$$

As explained in [15], there are three types of coverage. (1) Raw coverage refers to the proportion of cases that exhibit the outcome that the causal input explains regardless of conceptual overlap with other causal inputs. (2) Unique coverage refers to the proportion of cases that exhibit the outcome that a causal input uniquely covers. (3) Unique coverage is conceptually similar to "partitioned (or unique) variance" in multiple regressions. Finally, solution coverage refers to the proportion of cases that exhibit the outcome that is covered by all causal inputs (or causal recipes).

Table 1 Distributions of the outcome and indicator variables for the smallholder farmers

Variables	Original Range	Original mean	Fuzzy-set mean
Outcome variables			
Productivity	1–3	2.31	0.64
Profitability	1–3	2.38	0.67
Production quality	1–3	2.24	0.61
Conditions/indicator variables			
Formal education	1–3	1.84	0.43
Farm organizational skill	1–3	2.60	0.77
Farm record-keeping	1–3	2.46	0.71
Farming skill	1–3	2.48	0.71

Source: own analysis [2020]

Results and discussion

Descriptive statistics of data

As depicted in Table 1, the average value of productivity, profitability and product quality of the horticultural crops laid down at a medium level. Moreover, the average values of the socioeconomic and demographic characteristics of the smallholder farmers are placed at a medium level except their formal education level. The majority of the Ethiopian smallholder farmers have either uneducated or low level of formal education. However, those smallholder farmers have an excellent experience in farming skill and farm organizational skills to cultivate horticultural crops and other agricultural activities because their average value of these two causal conditions is approached to three (high value).

Sources of information for horticultural farming

As illustrated in Fig. 4, we identified four sources of horticultural farming information. These are, 43.75% of the sample households have gained horticulture farming information from governmental agricultural extension offices, while 30% received from non-governmental organizations (GIZ, and others). For the sample households, 17.5% of the sample households relied on peer groups who have neighbor farmers and actively engaged/attached to different extension services providers and public media. Moreover, the very little sample of households (8.75%) has acquired horticulture farming information through media (television, radio, and free mobile calling services). This percentage surprised us that we expected to get more percentage on it because the study area is very close to the capital city of the region (Bahir Dar). That means, due to the availability of the head office of different governmental and non-governmental organizations, several households would get farming information through media. We perceived in this finding that the government agriculture extension service or public extension service is the most pertinent source of farm information for smallholder farmers than others.

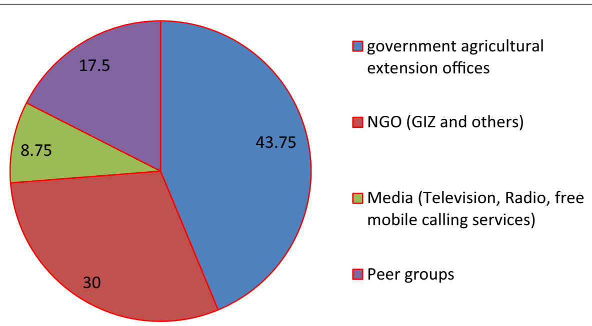

Fig. 4 The main sources of information for horticulture farming. Source: own analysis (2020)

Information provision for different agricultural activities

Multiple types of farm information are essential for farmers to successfully perform farming activities to yield high production and productivity. As illustrated in Fig. 5, we investigate eight type of farm information provision in their farming activities. Among these, about 26.25%, 17.5%, and 17.5% of the sample smallholder farmers obtained information of chemical fertilizer use, improved crop varieties, and weed management technology, respectively. However, we observe in this figure, there is low information provision for smallholder farmers regarding weather prediction, improved irrigation technology and postharvest technology for horticultural crops.

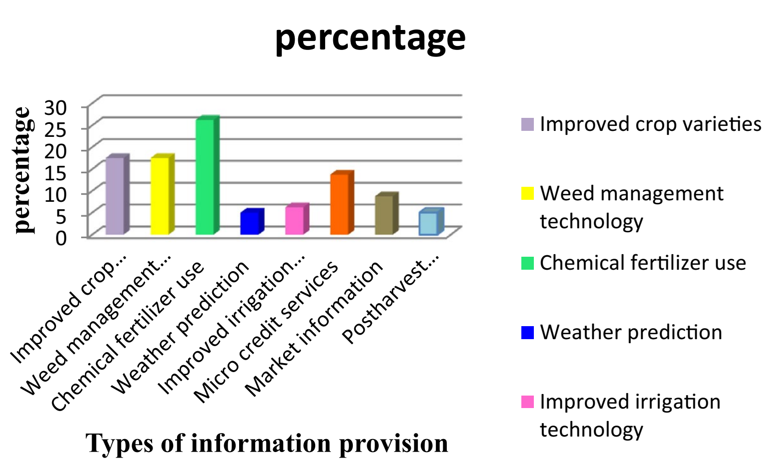

Fig. 5 Information provision for different agricultural activities. Source: own analysis (2020)

Level of farmers' satisfaction in terms of getting the agricultural information

The utility level of farmers in terms of obtaining the agricultural information is illustrated in Fig. 6 which is a five level of ordinal measurement. The result reveals that about 42.5 percent of the sample farmers are moderately satisfied in terms of getting agricultural information, while only 26.25% are satisfied, 11.25% are satisfied to some extent, and 12.25% are not satisfied at all. The evidence shows that only 7.5% of the sample farmers are highly satisfied. Thus, the finding shows that farmers have low level of satisfaction on getting the agricultural information in the study area; the reason might be the quality of the agriculture information delivery by the providers.

Results of the direct calibration approach

Based on the direct calibration method in Table 2, the threshold for full membership, full non-membership, and cross-over point for the productivity of the horticultural crops for the smallholder farmers are 0.95, 0.5, and 0.05, respectively. Based on the given data available, we calibrated full membership, crossover point, and full non-membership when the smallholder farmers have a high, medium, and low value of the outcome variables and causal conditions, respectively. About 53.75% of the sample households have a high level of profitability of horticultural crops, while about 38.47% of the households have a high quality of product for horticultural crops. This shows that the majority of the households will have either low or medium product quality for the horticultural crops.

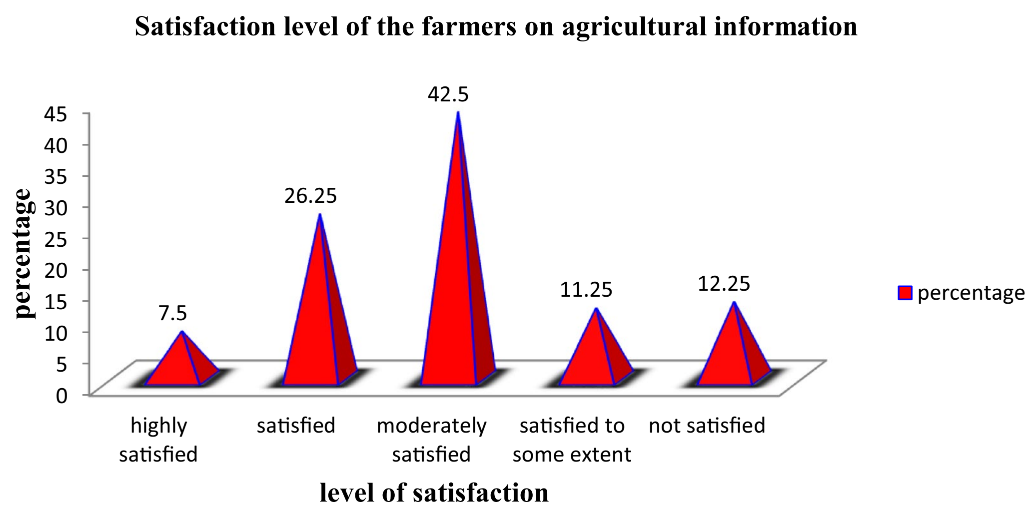

Fig. 6 Level of farmers' satisfaction in terms of getting agricultural information. Source: own analysis [2020]

Table 2 The output of the direct calibration method of data conversion original data to fuzzy-set

Variables	Full membership			Cross-over point (maximum ambiguity)			Full non-membership		
	Fuzzy score	Obs	%	Fuzzy score	Obs	%	Fuzzy score	Obs	%
Outcome variables									
Productivity	0.95	40	50.00	0.5	25	31.25	0.05	15	18.75
Profitability	0.95	43	53.75	0.5	24	30.0	0.05	13	16.25
Production quality	0.95	31	38.75	0.5	37	46.25	0.05	12	15.00
Conditions/indicator variables									
Formal education	0.95	14	17.50	0.5	39	48.75	0	27	33.75
Farm organizational skill	0.95	56	70.00	0.5	16	20.0	0	8	10.00
Farm record-keeping	0.95	44	55.00	0.5	29	36.25	0	7	8.75
Farming skill	0.95	48	60.00	0.5	22	27.50	0	10	12.50

Source: own analysis [2020]

Results of the coincidence matrix

The sets of the high formal education and high productivity of horticultural crops overlap by 72% of their possible shared area as shown by their 0.721 coincidence score which is the lowest coincidence score. We also see that the sets of high farm organizational skill with high productivity and with product quality of horticultural crops is the single set that has the most coincidence score among the possible combinations/ configurations. The high formal education level and high profitability sets overlap by 87% of their possible shared area as shown by their 0.867 coincidence score (Table 3).

Analysis of sufficiency and necessity conditions

As depicted in Table 4, high farm organizational skill and high formal education level are the most sufficient conditions for predicting the productivity, profitability, and product quality with a consistency score of 0.751, 0.867, and 0.828, respectively. In general, we also see that the necessity and consistency score for each causal condition is above 0.50 except the necessity value of education in productivity of horticultural crops. On the other hand, based on sufficiency and necessity matrix, the least sufficient for predicting high productivity, profitability, and product quality of horticultural crops of the smallholder farmers are formal education, farming skill, respectively (Table 4).

What combination of agricultural information literacy indicators or conditions is sufficient for the high productivity performance of horticultural crops?

After doing multiple iterations for the reduction of the configuration of causal conditions or predictors (to get the true configurations), the combination of high farm organizational skill and high farming skill is consistently sufficient for high productivity of horticultural crops. The combination of high farm record-keeping skills and high farming skills are also consistently sufficient for gaining high production profitability of horticultural crops. Moreover, the combination of high farm organizational skills, high farm record-keeping skills, and high farming skills are consistently sufficient for causing high product quality of horticulture crops. Based on the Ragin's definition on fuzzy-set construction [28], the consistency score for the true combination of the configurations in this study is above 0.75. Thus, those true combinations

Table 3 Analysis of the coincidence matrix for the outcome against the conditions/predictors

Productivity					
	P	E	O	R	F
P	1.000				
E	0.721	1.000			
O	0.903	0.894	1.000		
R	0.797	0.867	0.840	1.000	
F	0.824	0.881	0.889	0.848	1.000
Profitability					
	B	E	O	R	F
B	1.000				
E	0.867	1.000			
O	0.831	0.894	1.000		
R	0.789	0.867	0.840	1.000	
F	0.780	0.881	0.889	0.848	1.000
Production quality					
	Q	E	O	R	F
Q	1.000				
E	0.828	1.000			
O	0.898	0.894	1.000		
R	0.860	0.867	0.840	1.000	
F	0.860	0.881	0.889	0.848	1.000

Source: own analysis [2020]

The capital letter P, B, Q, E, O, R, and F indicate productivity, profitability, production quality, formal education, farm-organizational skill, farm record-keeping, and farming skill, respectively

Table 4 Analysis of sufficiency and necessity conditions of the outcome and predictors

Productivity					
	P	E	O	R	F
P	1.000	*0.480*	*0.903*	*0.797*	*0.824*
E	***0.721***	1.000	0.894	0.867	0.881
O	***0.751***	0.494	1.000	0.773	0.824
R	***0.721***	0.521	0.840	1.000	0.848
F	***0.739***	0.525	0.889	0.842	1.000
Profitability					
	B	E	O	R	F
B	1.000	*0.552*	*0.831*	*0.789*	*0.780*
E	***0.867***	1.000	0.894	0.867	0.881
O	***0.721***	0.494	1.000	0.773	0.824
R	***0.745***	0.521	0.840	1.000	0.848
F	***0.731***	0.525	0.889	0.842	1.000
Production quality					
	Q	E	O	R	F
Q	1.000	*0.581*	*0.898*	*0.860*	*0.860*
E	***0.828***	1.000	0.894	0.867	0.881
O	***0.707***	0.494	1.000	0.773	0.824
R	***0.737***	0.521	0.840	1.000	0.848
F	***0.731***	0.525	0.889	0.842	1.000

Source: own analysis [2020]

The capital letter P, B, Q, E, O, R, and F indicate productivity, profitability, production quality, formal education, farm-organizational skill, farm record-keeping, and farming skill, respectively. The "bold italic" and "italic" emphasis indicates the value the sufficiency and necessity scores, respectively

might have an impact on the outcome variables. As illustrated in Table 5, farming skill (efficient use of resources) are the most consistent and sufficient to gain the cause of high productivity, profitability, and product quality of horticultural crops. The reasons beyond these configurations might when farmers have excellent ability and experience on farm organization, documenting, and overall farm operations, and farming experience; they might gain

Table 5 The intermediate solution for high productivity performance of horticultural crops

Configurations	Raw coverage	Unique coverage	Consistency
High productivity of horticultural crops			
Organizational skill and farming skill (O*F)	0.771	0.771	0.778
Total coverage	0.771		
Solution consistency	0.778		
High profitability of horticultural crops			
Farm record-keeping and farming skill (R*F)	0.679	0.679	0.756
Total coverage	0.679		
Solution consistency	0.756		
High production quality of horticultural crops			
Organizational skill and farm record-keeping and farming skill (O*R*F)	0.730	0.730	0.822
Total coverage	0.730		
Solution consistency	0.822		

Source: own analysis [2020]

the potential maximum level of yield, return and produce a better quality of horticultural crops. Thus, the drivers that affect the horticulture farming will not be an individual specific rather it might be a combination of two or three factors together or configurational effects.

Conclusions and policy implications

The main aim of this study was to assess the connection between combinations of farmers' agricultural information literacy and productivity performance of horticultural crops in Ethiopia. The substantive knowledge of the link between information literacy and productivity performance of the horticultural crops tells us that causation is more complex or combinatorial; thus, it is unlikely to identify the impact of the causal conditions on the outcome variables through conventional quantitative methods rather it is better to use the fsQCA approach. We identified four sources of horticultural farming information: these are governmental agricultural extension offices, non-governmental organizations (GIZ, and others), peer groups, and media (television, radio, and free mobile calling services). There was better information provision for smallholder farmers on chemical fertilizer use, improved crop varieties, and weed management technology in the study area, while information provision for smallholder farmers regarding weather prediction, improved irrigation technology and postharvest technology for horticultural crops is very low.

The results of the fsQCA indicated that high or low productivity performance of horticultural crops could be affected by a combination of farmers' agricultural information literacy conditions. The results show that a configuration of two or three conditions include the high levels of farm organizational, farm record-keeping, and farming skills to be consistently sufficient to attain high productivity performance of the horticultural crops. This result is in line with the concept of the asymmetric causality of the conditions [27, 35]. Thus, provision of information for smallholder farmers regarding weather prediction, improved irrigation technology and postharvest technology for horticultural crops should be promoted. Improving the joint information literacy effects of the farmers regarding their organizational, farm recording, and farming skills should give due attention by the policy makers and practitioners to enhance the productivity performance of the horticultural crops in the study area. Moreover, future analysis might apply our approach to other relevant issues for information literacy conditions to define a comprehensive set of policy interventions to enhance the productivity performance of the horticultural crops in Ethiopia and other agrarian countries.

Abbreviations
CIA: American Central Intelligence Agency; CSA: Ethiopian Central Statistical Agency; fsQCA: Fuzzy-set qualitative comparative analysis; FWAO: Fogera Woreda Agriculture Office; Ha: Hectare; ICT: Information and Communication Technology; Km: Kilometers; m.a.s.l: Meter above sea level; NPC: Ethiopian National Planning Commission; %: Percent; IPMS: Improving Productivity and Market Access; UNDP: United Nations Development Programme.

Acknowledgements
The authors are grateful to the Fogera district Agriculture and Rural Development Office for permission to conduct this research. Thanks also go to the four anonymous reviewers.

Authors' contributions
AAF is a lecturer and researcher in the department of Agricultural Economics at Debre Tabor University. Asmiro obtained his bachelor and master degrees in Mekelle University (Ethiopia) and Bonn University (Germany), respectively. He carried out various research activities in the areas of agricultural technology adoption and dis-adoption analysis, value chain analysis, farm efficiency analysis and related socioeconomic studies. He did, in this study, initiated the research work, data collected, wrote the proposal and all the follow-up tasks like data entry to computer, data cleaning, model selection, analysis, and produces the manuscript. He read and approved the final manuscript. GGG is an assistant professor in faculty of environment, gender and development studies at Hawassa University, Ethiopia. Dr. Gebre has PhD in Agriculture and Resource Economics from Kyushu University, Japan. He has MSc in Economics (Development Policy Analysis) from Mekelle University, Ethiopia and MSc in Agricultural Production Chain Management (Horticulture Chain) from Van Hall Larenstein University of Applied Sciences, the Netherlands. He did many-fold research activities in the area of gender-based research, agricultural marketing analysis, value chain analysis, agricultural policy analysis and related socio-economic studies. He did, in this study, on the model selection, data analysis, manuscript writes up. He read and approved the final manuscript.

Funding
The author received no financial support for the research, authorship and/or publication of this article.

Availability of data and materials
The authors want to declare that they can submit the data at any time based on publisher's request. The datasets used and/or analyzed during the current study are available from the authors on reasonable request in STATA 14.0 format.

Declarations

Ethical approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
[1] Department of Agricultural Economics, Debre Tabor University, Debra Tabor, Ethiopia. [2] Faculty of Environment, Gender and Development Studies, Hawassa University, Awassa, Ethiopia.

Received: 14 September 2020 Accepted: 2 April 2021
Published online: 06 September 2021

References
1. Ademola A, Olatokun W. Agricultural information sources and literacy of fruit farmers: a qualitative enquiry. 2018. http://doi.org/https://doi.org/10.2139/ssrn.3123707. Accessed 20 Aug 2020.

2. American Central Intelligence Agency (CIA). Africa: Ethiopia; the World Fact book - Central Intelligence Agency. 2017. https://www.cia.gov/library/publications/the-world-factbook/geos/et.html. Accessed 17 Nov 2018.
3. Amhara National Regional State Bureau of Agriculture (BoA). Working document on the Amhara Region Horticulture Development Strategy (2015–2019); 2015. Bahir Dar, Ethiopia.
4. Chavula HK. The role of ICTs in agricultural production in Africa. J Dev Agric Econ. 2014;6(7):279–89.
5. Connell TH, Franklin C. The internet: educational issues (libraries and the internet: education, practice and policy). Libr Trends. 1994;42(4):608–26.
6. Dufera GL. The Ethiopian agricultural extension system and its role as a development actor: cases from Southwestern Ethiopia (Ph.D. Dissertation). Bonn University, Bonn, Germany; 2018.
7. Eric OO, Prince AA, Alfreda ANA. Effects of education on the agricultural productivity of farmers in the Offinso Municipality. Int J Dev Res. 2014;4:1951–60.
8. Ethiopian Statistical Agency (CSA). Area and Production of Major crops in Ethiopia (Statistical report). Central Statistical Agency, Addis Ababa, Ethiopia. 2018; vol: 1, Statistical Bulletin 586.
9. Falcone PM, Lopolito A, Sica LE. Policy mixes towards sustainability transition in the Italian biofuel sector: dealing with alternative crisis scenarios. Energy Res Soc Sci. 2017. https://doi.org/10.1016/j.erss.2017.09.007.
10. Falcone PM, Rosa SP. Use of fuzzy cognitive maps to develop policy strategies for the optimization of municipal waste management: a case study of the land of fires (Italy). Land Use Policy. 2020. https://doi.org/10.1016/j.landusepol.2020.104680.
11. Falcone PM. Tourism-based circular economy in Salento (South Italy): a SWOT-ANP analysis. Soc Sci. 2019;8:216.
12. Farrington J. The changing public role in agricultural extension. Food Policy. 1995;20(6):537–44.
13. Fogera Woreda Agriculture Office (FWAO). The Socioeconomic Characteristics of the Smallholder Farmers in Fogera Woreda. 2020. Working Documents and Training Manual, Fogera, Ethiopia.
14. Improving Productivity and Market Success (IPMS). Fogera Pilot Learning Woreda diagnosis and program design. 2005.
15. Jibat GA. Horticultural crops production in Ethiopia. Horticulture Research Division: Oromiya Agricultural Research Institute; 2003.
16. Kent RA, Argouslidis PC. Shaping business decisions using fuzzy-set analysis. J Market Manage. 2005;21(5–6):641–58.
17. Klasen M, Reimers S. Revisiting the role of education for agricultural productivity. Revised version of the discussion paper of the courant research centre "Poverty, Equity and Growth", No: 90, November, 2011.
18. Kokkinos K, Karayannis V, Konstantinos MK. Circular bio-economy via energy transition supported by Fuzzy Cognitive Map modeling towards sustainable low-carbon environment. Sci Tot Environ. 2020;2020(721):137754. https://doi.org/10.1016/j.scitotenv.2020.137754.
19. Lee, S. S. A critique of the fuzzy-set methods in comparative social policy. Oxford: University of Oxford. 2008. http://www.compasss.org/wpseries/Lee2008.pdf. Accessed 03 Feb 2021.
20. Longest K, Vaisey S. Fuzzy: a program for performing Qualitative Comparative Analyses (FSQCA) in STATA. STATA J. 2008;8(1):79–104.
21. Malapela T, Keizer J. The role of AGRIS in providing global agricultural information to boost productivity and food security; 2014.
22. Mashroofa M, Senevirathne W. Influence of information literacy skills in accessing agricultural information with special reference to Paddy Farmers of Ampara District, Sri Lanka; Paper presented at IFLA Conference in Lyon, July 21–25, 2014.
23. National Planning Commission (NPC). Gowth and transformation plan II (2015/16–2019/20)). National Planning Commission, Addis Ababa, Ethiopia. 2016.
24. Pappas N, Papatheodorou A. Tourism and the refugee crisis in Greece: perceptions and decision-making of accommodation providers. Tour Manage. 2017;63:31–41. https://doi.org/10.1016/j.tourman.2017.06.005.
25. Paykani T, Rafiey H, Sajadi H. A fuzzy-set qualitative comparative analysis of 131 countries: which configuration of the structural conditions can explain health better? Int J Equity Health. 2018. https://doi.org/10.1186/s12939-018-0724-1.
26. Quintin G, Tefera A. Ethiopia grain and feed annual report (No. ET-1301); 2013.
27. Ragin C. Fuzzy-set social science. Chicago: University of Chicago Press; 2000.
28. Ragin C. Redesigning social inquiry: fuzzy-sets and beyond. Hoboken: Wiley; 2008.
29. Rapsomanikis G. The economic lives of smallholder farmers. Food Agric. Organ. U. N. FAO Rome 48. 2015. https://www.fao.org/publications
30. Sang NC, Cheruiyot JK. Farmers' information literacy and productivity performance of smallholder horticulture in a highland zone, Kenya. J Sci Res Rep. 2020;26(6):89–99.
31. Schneider CQ, Wagemann C. Standards of good practice in qualitative comparative analysis (QCA) and fuzzy-sets. Comp Sociol. 2016;9:397–418.
32. Stevens A. Configurations of corruption: a cross-national qualitative comparative analysis of levels of perceived corruption. Int J Comput Sociol. 2016;57:183–206.
33. Tadesse D. Access and Utilization of Agricultural Information By Resettler Farming Households: The Case Of Metema Woreda, North Gondar, Ethiopia. MSc thesis research at Haramaya University. Ethiopia. 2008.
34. Tepes A, Neumann BM. Multiple perspectives of resilience: a holistic approach to resilience assessment using cognitive maps in practitioner enga*gement*. Water Res. 2020;178:115780. https://doi.org/10.1016/j.watres.2020.115780.
35. Ordanini A, Parasuraman A, Rubera G. When the recipe is more important than the ingredients: a qualitative comparative analysis (QCA) of service innovation configurations. J Serv Res. 2014;17:134. https://doi.org/10.1177/1094670513513337.
36. UNDP. Promoting ICT based agricultural knowledge management to increase production and productivity of smallholder farmers in Ethiopia. Development Brief. 2012; Number 3/2012.
37. World Bank. Agriculture, forestry, and fishing, value added (percent of GDP) of Ethiopia. 2017.
38. Yamane T. Statistics: an introductory analysis. 2nd ed. New York: Harper and Row; 1967.
39. Zhong X, Qu K. The investigation and analysis of the new generation farmers' information literacy in Chongqing Province. 2013. https://doi.org/https://doi.org/10.2991/asshm-13.2013.156.

Publisher's Note