Character strengths and sustainable technology adoption by smallholder farmers

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A B S T R A C T
Sustainable food systems are required to feed a growing world population. Smallholder farmers, who produce a significant share of the food supply in many developing countries, can play a crucial role in applying such systems. In agriculture, various innovative technologies promise to have a significant impact on securing a sustainable future. Clearly, however, before new technologies can benefit their users, they must first be adopted. Why do most smallholders avoid using modern cultivation technologies? Rather than focusing on socio-economic geography-related factors and information gaps, we offer a new perspective, suggesting that personal variables, such as character strengths, prompt the adoption of sustainable technologies. We put this hypothesis to an empirical test in a large-scale field study of drip irrigation (DI) adoption in Senegal. Data were collected by face-to-face questionnaires. A binary logistic regression analysis of the data obtained from 335 different plots in Senegal, showed a significant connection existed between two character strengths, creativity and judgment, and DI adoption. Along with its theoretical and empirical contribution, the value of this study lies in its practical implications: The research focuses on variables that are malleable and likely to be influenced by policy tools and education.

Q6 1. Introduction

The global food system faces the challenge of meeting rising food demands for an ever-growing population. The global population is projected to reach nine billion people by 2050, which requires an immense increase in food production (FAO, 2009). Achieving such growth without aggravating environmental problems is a significant concern. Clearly, food systems that are economically, socially, and environmentally sustainable should be found, in order to adequately feed the world’s population.

Smallholder farmers predominantly live in developing countries. They cultivate small parcels of land for their living, making little use of modern inputs (Altieri and Koohafkan, 2008; Morton, 2007). Despite their typically low yields, smallholders produce a significant share of the food in many developing countries, making their farming crucial for poverty alleviation, food security, and sustainable food systems (Parry, 2007; Samberg et al., 2016; Thornton et al., 2018).

Such farmers also dominate Senegal’s agricultural production (Diagne and Cabral, 2017; Wane et al., 2015). In Senegal, climate change, in the form of unpredictable seasonal rains and drought, hinders the development of more sustainable agriculture. Climate-related shocks such as droughts and floods lead to a higher rate of soil erosion, salinization in agricultural soils, and destruction of critical infrastructure. Nevertheless, less than 10 percent of cultivated land is under irrigation, making Senegalese agriculture profoundly dependent on rainfall (Franzel et al., 2018). Adopting agricultural technologies, such as water-saving technologies, or drought-resistant varieties (Biagini et al., 2014), may enable better adaptation of the agricultural systems to the changing climate (Biagini et al., 2014). For example, farmers may be more tolerant to drought by using water-saving technologies. Such technologies increase the use efficiency of the available water and reduce water loss (Chartzoulakis and Betrakli, 2015). Farmers can also use drought resistance plant varieties which can overcome arid or drought conditions (Tirado and Cotter, 2010).

Poor farming practices and multiple other issues, from financial credit to land tenure, and gender discrimination exacerbate the situation (Diagne and Cabral, 2017; Nation, 2010; Nguyen et al., 2017; Sunding and Zilberman, 2001; Totin et al., 2015; Tschakert, 2007; Wane et al., 2015). Similar to other developing countries (e.g., Malawi, Ethiopia, Kenya, Tanzania, and Uganda), the poor performance of Senegal’s agricultural sector is also due to a limited take-up of productivity-enhancing inputs and technologies among smallholder farmers (Chinseau et al., 2010).
technological innovation (Bukchin and Kerret, 2018). Despite the po-
are predicted to in
2. Theoretical framework
further research, followed by several recommendations.
creativity, judgment (i.e., open-mindedness, critical thinking), and
and hypotheses, suggesting that character strengths (CS), are associated
with agricultural technology adoption by farmers. Speci-
approach, combining positive psychology and sustainable development
social-cultural-ecological contexts (Brown, 2014; Shah et al., 2017).
these barriers fail, however, to explain in full the dynamics of tech-
ology adoption by farmers, as their removal does not guarantee that a
particular innovation would be actually adopted. A previous investiga-
based on anecdotal evidence from various case studies, indicated that economic factors alone do not explain
convincingly why agricultural technologies are adopted or rejected by
farmers. To date, literature based on an empirical study of the adopters is
scarce (Esham and Garforth, 2013), and much remains unknown about
the adoption of technological means by farmers. Other studies suggest
that the existent research on agricultural technology adoption ignores
innovative research methodologies and lacks a holistic, robust, inter-
disciplinary perspective (Glover et al., 2016; Sun et al., 2015). Moreover,
researchers have been calling to theorize resilient, intangible, and
non-material dimensions of agriculture (e.g., subjective, emotive, and
relational forms) that emerge from specific local
Given the literature gap and the lack of comprehensive analysis of
factors affecting smallholders’ decision-making processes on technology
adoption, the present study introduces an innovative interdisciplinary
approach, combining positive psychology and sustainable development studies. The paper begins with a description of our theoretical framework and hypotheses, suggesting that character strengths (CS), are associated with agricultural technology adoption by farmers. Specifically, three CS: creativity, judgment (i.e., open-mindedness, critical thinking), and perspective are hypothesized to be correlated with adopting technology, as they are associated with complex problem solving, better analyzing skills, and generating innovative ideas. To support this hypothesis, we conducted a field study in Senegal, in which we examined the connection between these CS and technology adoption. Data collected from 335 plots by a face-to-face questionnaire were analyzed using binary logistic regression analysis. A discussion of the survey findings follows a short review of the research methodology. Finally, directions are proposed for further research, followed by several recommendations.

2. Theoretical framework

We suggest that character strengths (CS), namely, personal resources, are predicted to influence the decision of whether or not to adopt a technological innovation (Bukchin and Kerret, 2018). Despite the potential benefits of utilizing CS for the implementation of sustainable
technologies, researchers and practitioners have typically focused their attention on character flaws and barriers (Bukchin and Kerret, 2018). In line with our positive psychology orientation, we follow the theory put forward by Peterson and Seligman (2004). They define CS as human capacities to feel, think, and behave in ways that benefit others and themselves. While all humans possess all of Peterson and Seligman (2004) 24 CS (e.g., creativity, curiosity, bravery, fairness, self-regulation, and judgment), each individual is unique in using a specific set of strengths, hence the differences in the overall application of strengths. Peterson and Seligman’s theory also identifies six classes of “core virtues” (transcendence, temperament, justice, humanity, wisdom, and courage), that are derived from the 24 measurable CS.

Based on Peterson and Seligman’s theory, we hypothesize that specific character strengths may be more closely associated with sustainable technology adoption. Our initial investigation focuses on three specific strengths: creativity, judgment (i.e., open-mindedness), and perspective.

All three strengths belong to the “wisdom” virtue. Peterson and Seligman (2004) define this core virtue as knowledge hard fought for and then used for good. It is a form of noble intelligence that is not synonymous with general intelligence or academic honors. The virtue of wisdom involves strengths related to the way knowledge is acquired and used (Kramer, 2006; Peterson and Seligman, 2004; Sternberg, 1998). As such, it is thought to be highly relevant to looking for technological information and adopting a specific technology. We have chosen to explore a narrower scope of CS than originally proposed by Peterson and Seligman (2004), based on recent research that argues for careful selection of context-specific strengths (Sosis et al., 2012). The following section describes our theoretical framework, suggesting that a relation exists between sustainable technology adoption and creativity, perspective, and judgment.

Judgment (open-mindedness, critical thinking)

The wisdom-related strength of judgment stands for the ability to adopt a balanced and objective mindset when engaging in complex problem solving (Peterson and Seligman, 2004). People with a high capacity for judgment tend to think matters through and examine them from all aspects. They do not jump to conclusions and prefer relying on substantial evidence in making decisions. They use cognitive skills or strategies that increase the probability of a desirable outcome (Halpern, 2013), and are known for weighing all evidence fairly (Neimec, 2017; Peterson and Seligman, 2004). Judgment is also a “corrective virtue” that counteracts faulty thinking and biased opinions, thus enhancing decision making (Neimec, 2017). It is linked with a willingness to search for evidence supporting one’s favorite beliefs, plans, or goals (Peterson and Seligman, 2004). Given that evidence regarding the adoption of sustainable technologies is favorable towards adoption, farmers that investigate adoption should decide to adopt technologies.

This CS is often used to describe a way of thinking that is purposeful, reasoned, and goal-directed. Such thinking is often related to problem-solving, inference, likelihood evaluation, and decision making, where the thinker uses skills that reflect contemplation and are effective in a particular context and for a specific purpose (Halpern, 2013). People with enhanced judgment tend to apply their skills to learning new techniques effectively, and associate newly acquired knowledge with previously obtained information (Halpern, 2013).

Another aspect of this strength is open-mindedness. People with high judgment capacity are commonly thought to be broad-minded and flex-
ible in approaching change (Peterson and Seligman, 2004). Moreover, open-mindedness about change has been shown to generate highly creative outcomes (George and Zhou, 2001).

Accordingly, we suggest that farmers with a high capacity for judgment are likely to strategize, contemplate and weigh the possible results of technology adoption, and probably be able to think beyond the initial investment and envisaged difficulties and see the anticipated positive outcomes. A farmer with good judgment, who grew up on a farm and was
taught to use specific farming practices, might actively challenge these practices, applying his ability to counteract faulty thinking and biases. Goal-directed thinking and a drive to solve problems, which characterize farmers with good judgment, would encourage adopting new technologies and practices to enhance farm productivity. Good judgment may urge farmers to acquire new skills that are needed for technology adoption, such as how to install and manage the new technology. Lastly, as adopting and experimenting with a new technology clearly involves lifestyle changes that would require broad-mindedness and flexibility, people with good judgment would be likely to venture them. Based on the above, we hypothesize that people with high judgment strength are more likely to adopt new technologies.

Perspective

In the literature, perspective, also referred to as “wisdom” (Peterson and Seligman, 2004), has a number of definitions that spring from different theoretical and methodological approaches. Peterson and Seligman (2004) maintain that this character strength is distinct from intelligence, representing a superior level of knowledge, judgment, and advisory ability. Moreover, the introspective qualities of perspective enable one to view the same idea from different aspects, generate permutations, and consequently produce more possibilities for consideration. Ultimately, given this breadth of options, the perspective may yield a primary outcome (Avey et al., 2012).

In the context of organizational research, Mumford et al. (2009) suggest that perspective provides executives with more information and greater cognitive ability towards performing effectively five key executive tasks: (1) scanning, namely, assessment of a competitor’s strengths and weaknesses, and integration of competitor and customer views into own strategy; (2) case analysis, and (3) forecasting, which facilitates trend identification within industries; (4) idea generation, and (5) planning.

Farmers require a broad perspective capacity to better understand the strengths and weaknesses of technologies, select trends that are relevant to their farm, gather different views (i.e., those of suppliers or other farmers), and integrate them into a holistic vision. Perspective helps accomplish these cognitive tasks as it comprises skills that enable integrating viewpoints different than one’s own (Neimiec, 2017; Peterson and Seligman, 2004).

It is possible to regard the heads of farming households as executives, who are in charge of operating the farm—as such, having a broader perspective may assist them in performing effectively the five key executive tasks in their farms. Using their perspective strength, they will be able to scan different new available technologies against the ones that they already use, identify these technologies’ advantages and disadvantages, generate relevant ideas, and plan ways to advance their farming practices. Comprehensive analysis of sustainable technologies that are beneficial to both the farmer and the environment would assist the farmer in preparing to adopt new technology. Planning may also help the farmer overcome existing barriers (e.g., by saving initial investment money).

We hypothesize that farmers with a well-developed perspective are more likely to adopt innovative sustainable technologies, as it enables them to better understand the technology, gather and integrate different views regarding the technology, and analyze the information to acquire a holistic vision.

Creativity

Creativity, as defined by Peterson and Seligman (2004), consists of two essential components—originality and adaptiveness. A creative individual generates innovative or unusual ideas or behaviors that make a positive contribution to an individual’s life or the lives of others (Seligman and Csikszentmihalyi, 2000). Creative people are capable of thinking up a novel and productive ways of doing things but also of conceptualizing them (Neimiec, 2017). They can solve problems in innovative ways, and would not take the conventional path if a better option is available (Peterson and Seligman, 2004).

Feist (1998) maintains that creative people possess a unique set of traits. They tend to be independent, nonconformist, unconventional, likely to be open to new experiences, cognitively flexible, and bold in risk-taking. Zentasni et al., (2008) show empirically that tolerance for ambiguity interrelates with creativity moderately and positively. Similarly, higher levels of general creativity empirically predict higher levels of cognitive tolerance to risk (Charyton et al., 2013).

Creative farmers continuously seek innovative solutions. This suggests that they may view new technology as an upgrade, and appreciate it as potentially capable of helping overcome challenges such as climate change or food security. Given that creative farmers actively seek innovation, they are likely to take an interest in learning about recent innovations, rather than settle for current practices. Considering that they may regard technology as a way to overcome challenges and improve their yields, we suggest that they will be more likely to adopt it. Furthermore, farmers are known to be often risk-averse, and as such reluctant to adopt new technologies (Mukasa, 2018). Creativity may buffer their reluctance, making them more flexible, open to new experiences, and tolerant of ambiguity. It is, therefore, hypothesized that they are more likely to trust and adopt new technology.

2.1. The case for drip irrigation

Drip irrigation is a technology that may well play a significant role in climate change mitigation. Ultimately, its adaptation has the potential to enhance food security in countries such as Senegal. Thus, this was chosen as the technology that is explored in this case study. To produce food in quantities that would sustain the earth’s growing population, it is necessary to expand the land area under irrigation while at the same time using proportionately less water (FAO, 2009).

Drip irrigation systems save water and nutrients, trickling water slowly down to the roots of plants (Phocaides, 2007). This promises to increase land productivity and, consequently, the income of smallholders (Postel et al., 2001). Drip irrigation has several advantages that increase yields (Dasberg and Or, 2013): (1) higher water efficiency, resulting from direct application to the roots, and less water loss due to evaporation, runoff, and deep percolation; (2) fewer fluctuations in soil water content, and consequent avoidance of water stress; (3) improved agricultural practices such as fertilizer application and weed control (Dasberg and Or, 2013); and (4) reduced labor cost compared to other irrigation methods (Postel et al., 2001). Not only does drip irrigation save 50 percent of the water used in conventional irrigation methods, but it is likely to compensate for higher temperatures, namely, help agriculture adapt to global warming (Kurukulasuriya and Rosenthal, 2013).

Of Senegal’s total irrigable area, 30 percent is not yet irrigated (Paglietti and Machado Mendes, 2016). Despite the many advantages of drip irrigation, the greater part of Senegal’s irrigated area uses surface irrigation systems (Paglietti and Machado Mendes, 2016). A number of obstacles stand in the way of drip irrigation adoption: the system is quite costly (Phocaides, 2007), meaning that many farmers cannot afford the initial investment without taking risky loans or investing a considerable part of their limited resources in the new technology. To adopt drip irrigation, users must acquire new management and technical skills (Phocaides, 2007), and put much time and effort into obtaining such skills. Moreover, users are often faced with technical problems such as emitter blockage (clogging of the emitters due to inadequate filtration of water impurities) (Phocaides, 2007). In some of the studied areas, the land characteristics were found to be specifically problematic for drip irrigation. One problem that emerged was a high iron content in the water, which sometimes causes emitter blockage. Farmers are faced with the challenge of devising ways to overcome such obstacles.

Therefore, to increase the rates of drip irrigation adoption, farmers must have access to technology, sufficient financial resources, and the...
educational background required to acquire such skills. It is equally important, however, that they decide to adopt this technology and be willing to make the effort involved.

2.2. Hypotheses

Combined, the characteristics of drip irrigation and the character strengths discussed above, generate the following hypotheses:

(1) Creative farmers who constantly seek innovation, sophisticated solutions, and improvements are likely to appreciate a novel technology that might help overcome challenges such as climate change and food security. Given that these farmers are also more tolerant of ambiguity, they are even more likely to take a bold decision and adopt the new technology.

(2) Farmers with a high sense of perspective are likely to better understand the strengths and weaknesses of the technology. They will gather and integrate different views into a holistic vision and devise ways to move forward with their farming practices. By planning, they may also remove specific barriers (e.g., save money for initial investment). Since drip irrigation has many advantages for both the farmer and the environment, a broad perspective is expected to yield an analysis that would encourage farmers to adopt this new technology.

(3) Lastly, farmers with a developed capacity for judgment will weigh different options and rely on substantial evidence in deciding whether to adopt drip irrigation. Given that adopting drip irrigation can potentially have a positive influence on the farmer's life, a full examination of this technology should lead to the decision to adopt it. Moreover, these farmers will be open to change and willing to gain the required new skills.

3. Method

3.1. Sample and procedure

Three highly experienced enumerators, one coordinator, and one researcher were involved in collecting the survey data by face-to-face interviews. The enumerators underwent preparatory training before testing the questionnaire on farmers. The training sessions yielded useful feedbacks that were incorporated into the final structured questionnaire.

The enumerators were tasked with driving to villages around Thies and engaging in conversations with farmers who met the following specifications: 1) Owned up to 10 ha of land; 2) Were the ones who mainly decide the nature of the household’s agricultural enterprises; 3) Took individual agricultural decisions (as opposed to group decisions); and 4) Grew vegetables. As per the second specification, we note that in some cases, agrarian production decisions are not made by a specific person. Though not ideal, we aimed to interview a dominant decision-maker on the farm. The ethical aspect of the study were approved by the Tel Aviv University Institutional Review Board. For robust statistical analysis, we sought to attain the largest sample possible. Yet, we wanted to work with a small, highly trained and qualified team of enumerators, who drove together in the designated areas to survey farmers. Thus, we decided to survey 383 plots.

The study followed the established ethical guidelines and regulations. All the participants joined the study on a voluntary basis and expressed their informed consent after being guaranteed anonymity. Finally, the main survey, consisting of face-to-face interviews of the enumerators with the farmers, was conducted in April and May 2018. In July 2018, the researchers visited several surveyed villages to get a first-hand impression of the holdings and verify the validity of the collected data.

The research participants were 335 farmers from the Thiès region in Senegal. Table 1 displays the sample demographics. In each plot, the only person interviewed was the household head, in charge of making the agricultural decisions. Thus, 335 farmers represent 335 plots. The average size of the cultivated area was 4.4 ha. Thirty-three of the farmers cultivated additional leased land; the average leased area in the sample was 0.26 ha. Note that the total number of surveyed plots was 383. Thirty-one records were removed, as they did not meet the above-mentioned conditions. By using a Stem and Leaf Plot, seventeen records were identified as outliers based on their yearly income and were removed from the sample as well. Thus, the final sample comprised of 335 participants.

3.2. Measures

Character strengths. To assess the levels of different character strengths in the farmers, we used the VIA-72 questionnaire. This measuring scale (Peterson and Seligman, 2004) consists of three statements per each of the 24 possible strengths. We used the statements for creativity, judgment, and perspective, namely nine statements in all. For example, one statement measuring perspective is “others consider me to be a wise person”; one statement measuring creativity is “I am always coming up with new ways to do things”; and one statement measuring judgment is “I always weigh the pros and cons.” If the whole 72-item questionnaire is used, the internal consistency reliability is .75 on average (α = .83 for creativity, α = .73 for judgment, α = .73 for perspective), and initial validity coefficients range from .36 to .48 (Peterson and Seligman, 2004). The farmers rated the statements on a 5-point Likert scale ranging from Very much like me (1) to Very much, unlike me (5).

Distance from Thies: Distances were calculated using the GPS coordinates acquired automatically in each farm. We used the haversine formula (Chopde and Nichat, 2013) to calculate the distance (in kilometers) from the closest city – Thies. Distance is a marker representing access to infrastructure.

Total annual income: Income was measured in West African CFA franc (XOF). It comprised income from agriculture as well as from other sources (private business, casual labor, formal employment by a company or the government, money transfers by migrants). Agricultural income was measured separately and was found to correlate positively (.335) and significantly (sig = .000) with the total income (using Pearson correlation). The annual income, therefore, refers to both agricultural income and the total sources of income.

Education: Number of respondent’s years of formal education.

Land suitability: The data on land suitability was provided by the local company Horticulture Agriculture en Afrique - H2A, which monitors local farmers and provides them with recommendations on irrigation and soil optimization. This is a binary scale, where 0 is low suitability (for example, due to high iron content in the water, risking to damage drip irrigation)

| Table 1. Sample demographics (N = 335). |
|---|---|---|---|
| Gender | 31 female, 304 men |
| Age | 19–75 |
| Household size | 5-31 (average of 13) |
| Ethnic group | Wolof | Pular | Serer | Other |
| | 66% | 20% | 12% | 2% |
irrigation systems if not addressed properly), and 1 is normal land suitability, where drip irrigation is easier to apply.

In addition to the above, the survey included general socio-demographic questions such as ethnicity, family size, and gender. The farmers were also asked whether they had received in the previous year any information on agriculture or technological samples (from the government, an NGO, an agricultural cooperative, or another source).

Lastly, to learn about ongoing irrigation routines, the farmers were asked to describe their irrigation techniques. If they claimed to be using drip irrigation, the enumerators checked the field to confirm the information and asked the farmers how long they have been using this technology.

### 3.3. Analysis

Because the dependent variable is binary (adoption vs. non-adoption of drip irrigation), binary logistic regression was applied to identify factors associated with adoption. Binary logistic regression estimates the probability that a characteristic is present (in this case, estimates the probability of drip irrigation adoption) given the values of explanatory variables, in this case: creativity; judgment; distance from Thies; total annual income; education; and land suitability. This method does not assume a linear relationship between the dependent variable and the independent variables. It is assumed that the logit transformation of the outcome variable has a linear relationship with the predictor variables. Thus, we will specifically focus on the odds ratio when interpreting the results. The odds ratio represents the constant effect of a predictor on the likelihood that the outcome (in this case, adoption of drip irrigation) will occur.

Eq. (1) represents the multiple logistic regression model used in this analysis. Though we conducted a binary regression, ordinary least squares (OLS) regression was used to rule out multicollinearity (Lewis-Beck, 1986), and take advantage of a greater choice of statistics that are easier to interpret. We used a maximum Variance Inflation Factor (VIF) threshold of 5 and a minimum tolerance threshold of 0.2 (Hair and Jnr, 2009; Kock and Lynn, 2012).

\[
\ln \left( \frac{p(\text{adoption})}{1 - p(\text{adoption})} \right) = B_0 + B_1 \times \text{judgment} + B_2 \times \text{creativity} + B_3 \times \text{perspective} + B_4 \times \text{education} + B_5 \times \text{land suitability} + B_6 \times \text{income} + B_7 \times \text{distance} + \varepsilon
\]  

(1)

### 4. Results

To investigate the character strengths measuring scale, factor analysis, and reliability analysis were conducted. The measuring scale consists of three items per each strength, and each item includes a statement that was rated by the farmers on a Likert scale. A principal component analysis was used to find out whether the items of the same scale all load on the same factor.

1. **Creativity**: One component was extracted. Item loadings were higher than 0.717. The Cronbach alpha for this scale was \( \alpha = .601 \) (3 items).
2. **Judgment**: One component was extracted. Item loadings were higher than 0.755. The Cronbach alpha for this scale was \( \alpha = .643 \) (3 items).
3. **Perspective**: Though only one component was extracted, item loadings were higher than 0.782 for two items, but the loading for the third item was only 0.366, suggesting that the scale is unreliable. The Cronbach alpha for this scale was \( \alpha = .376 \) (3 items). Based on the factor analysis, we calculated the Cronbach alpha using only the two items that loaded together in the factor analysis. However, the Cronbach alpha was still low \( \alpha = .501 \) (2 items). Consequently, we decided to discard the perspective in the final analysis.

Table 2 displays the descriptive statistics and correlations between all the study variables. Because the dependent variable is binary, binary logistic regression was applied to identify factors associated with adoption. Table 3 displays the maximum likelihood estimates (standardized) of the logistic regression model, the standard deviations, and the respective results of the Wald tests (df = 1). In addition to CS, the analysis also included and accounted for the following: distance from Thies (the nearest city), annual income, land suitability, and education. We also checked age, gender, household size, size of holding, and ethnicity, but none of these variables was found to affect the results significantly. Eight farmers (2.4%) stated that they had received some information on agriculture or technological samples over the previous year (from the government, an NGO, an agricultural cooperative, or another group or association). Since only two farmers reported they had received free drip irrigation systems, this factor was not included in the analysis.

The adoption of drip irrigation is explainable with a Nagelkerke R\( ^2 \) of 0.385, a significant model chi-square (chi-square = 96.97, df = 6, Sig. < .001), and log-2 likelihood of 256.8. The findings show that drip irrigation adoption is significantly and positively associated with creativity (B = .469 OR = 1.60, Sig. = .001), and with judgment (B = .572 OR = 1.77, Sig. = .008), supporting our hypothesis. It was also found to be significantly and positively associated with the total annual income (B = .1599 OR = 4.75, Sig. = .004), education (B = .311 OR = 1.37, Sig. = .033), and land suitability (B = .518 OR = 1.68, Sig. = .007), thus supporting the existing literature (Mignouna et al., 2011; Mwangi and Kariuki, 2015; Uaiene et al., 2009). Furthermore, in agreement with the literature, the adoption of drip irrigation was found to be inversely proportional to the distance from Thies (B = -.507 OR = .60, Sig. < .0008). When conducting a binary logistic regression, the odds ratio represents the constant effect of a predictor on the likelihood that the adoption of drip irrigation will occur. Notably, the relative effect of both strengths is high – a one-point rise on the creativity scale may increase adoption odds by 1.6, a one-point rise on the judgment scale may increase adoption odds by 1.77.

OLS regression was used to ensure that no strong multicollinearity exists between independent variables (see method section). The VIF and
Tolerance results confirmed that no strong multicollinearity existed (Table 3).

5. Discussion

The present study reveals a significant connection between character strengths (CS) and technology adoption. To date, the innovative CS factors have not been explored yet in this context. The study broadens the scientific understanding of variables connected with environmental technology adoption by smallholder farmers in developing countries. Despite their typically low yields, smallholder farmers produce a significant share of the food supply in many developing countries, making farming a crucial factor in both poverty alleviation and food security. The scientific evidence obtained offers an important empirical basis for future practical recommendations in the spheres of environmental policy, positive psychology, and innovation adoption.

The results of the quantitative analysis demonstrate that annual income, education, distance from the nearest city, and land suitability, are all associated with the adoption of drip irrigation. This adds empirical evidence to the literature, supporting the claim that such relationships actually exist (Cafer and Rikoon, 2018; Diirio, 2013; Mignouna et al., 2011; Mwangi and Kariuki, 2015; Uaiene et al., 2009). Given the high cost involved in purchasing a drip irrigation system, it is quite reasonable that income should strongly affect adoption odds. A higher education level improves a farmer’s general ability to access, process, and implement information relevant to technology adoption (Lavison, 2013; Mignouna et al., 2011). Education also helps farmers develop the skills required for using drip irrigation. Being distant from Thiès may prevent access to extension services, through which farmers learn about the availability of new technologies and the advantages of their use (Mignouna et al., 2011; Mwangi and Kariuki, 2015). Distance also disconnects farmers from the market, undermining their effort to sell yields, thus affecting income and the ability to invest in new technology. As for land suitability, farmers toiling to cultivate difficult land would obviously hesitate to cope with additional difficulty by adopting new technology.

Arguably, the most important contribution of this paper is that it shows a significant connection between two character strengths, judgment and creativity, and the adoption of drip irrigation by farmers in Senegal’s Thiès region. Not only are these strengths shown to be directly linked with the adoption of drip irrigation, but also their relative effect is stronger than that of various other factors that have been widely described in the literature, such as education and distance from the nearest city. A one-point rise on the creativity scale may increase adoption odds by 1.6; a one-point rise on the judgment scale may increase adoption odds by 1.77. These results suggest that in addition to access to the technology, means to make the necessary investment, and sufficient education to acquire the skills required to use the technology, farmers must be highly motivated to improve their farm, understand the technology to make the best use of its advantages, and be willing to make the effort of adopting it.

More specifically, the association between creativity levels and drip irrigation adoption fits well in the theoretical framework presented above (Charyton et al., 2013; Feist, 1998; Neimiec, 2017; Peterson and Seligman, 2004; Seligman and Csikszentmihalyi, 2000; Zenasni et al., 2008). Creative farmers constantly seek innovations, solutions, and improvements (Seligman and Csikszentmihalyi, 2000). Drip irrigation is a technology that has the potential to increase yields and help farmers cope with low water availability. Creative farmers are likely to appreciate such novel technology that might help overcome challenges (Neimiec, 2017; Peterson and Seligman, 2004). That these farmers are also more tolerant to ambiguity (Charyton et al., 2013; Feist, 1998; Zenasni et al., 2008), increases the likelihood that they would take the leap of faith and adopt the new technology, even though it is capital-intensive and may be initially difficult to manage.

The association between judgment levels and drip irrigation adoption could be explained by the implications of the developed judgment. Farmers with a developed sense of judgment would weigh the different options and decide whether to adopt drip irrigation or not based on solid evidence (George and Zhou, 2001; Halpern, 2013; Neimiec, 2017; Peterson and Seligman, 2004). Given that adopting drip irrigation is expected to have a desired positive effect on the farmer’s life, full examination of this technology would probably lead to its adoption. Moreover, such farmers will be open to change and willing to acquire the new skills required (Lounsbury et al., 2009). The actual benefits of drip irrigation to farmers in this context also need to be further explored. This is important as, in some cases, an increase in productivity may result in a decrease in wealth (Luna, 2020). Though we discuss evidence for the positive implications of sing drip irrigation, this matter may be further investigated for the specific ample, and in general.

The present study takes a first step towards demonstrating the important role of CS in choosing to adopt agricultural technologies. As such, it contributes to narrowing the current literature gap regarding factors affecting smallholders’ decision-making processes before adoption. CS are relevant to the vast majority of cultures throughout history (Peterson and Seligman, 2004). As such, they are likely to be relevant worldwide for people involved in different agricultural practices (Bukchin and Kerret, 2018; Peterson and Seligman, 2004). The association between CS and technology adoption should be further explored to cover various types of technology in other communities, as well as different usage purposes, and take into account intra-household dynamics. Future studies should also explore other CS and make use of more extended and more developed versions of the CS questionnaire (Peterson and Seligman, 2004).

To determine the precise type of intervention that will promote technology adoption and in order to suggest practical recommendations, additional empirical research should be conducted. Forthcoming studies should lean on a more diverse and larger sample, to validate further the findings of the current study. We are aware that the sampling of the present preliminary investigation risks being biased, because it examines a specific population. Although hard data were used to corroborate the respondents’ reports, self-reporting, and post-facto techniques are known to have weaknesses such as, selective memory, response biases, overstatement of motivations and positive self-attribution (Kormos and Gifford, 2014). Future research can also investigate a more elaborated...
6. Conclusions and policy recommendations

The role of CS was found to have in deciding to adopt a technology, suggests that development organizations, government agencies, and agricultural trainers will benefit from recognizing that it is possible to enlist farmers’ CS to promote technology adoption. Beyond merely focusing on farming techniques and financial means, training programs and demonstration farms could be used to boost the farmers’ CS. Moreover, policy programs could be designed to actively promote the relevant CS.

Unlike socio-economic factors, which are difficult to alter, CS are malleable and can be modified by policy tools and education. Therein lies the promise of this approach. Creativity may be built up using repeated interventions in different life stages, beginning in the education system (e.g. Bergen and Rousta, 2019; Egan et al., 2015; Jackson et al., 2006; Rababah et al., 2017), and continuing in adulthood (e.g. Feldman, 1999; Flood and Phillips, 2007; Sawyer et al., 2003). Based on evidence from educational policy documents around the world, Shaheen (2010) suggests that creativity remains neglected in many developing countries, whereas in developed countries, the educational philosophy and goals rely on enhancing creativity and self-actualization in students. In addition to including creativity-enhancing activity programs in schools, environments that are supportive, open, and informal are known to boost creativity, while time pressure, close supervision, and critical examination will curtail it (Neimiec, 2017). It is therefore recommended that NGOs and demonstration farms make an effort to provide potential adopters with an encouraging and unhurried environment.

To build up Judgment, various interventions could be devised (Halpern, 2013; Neimiec, 2017; Peterson and Seligman, 2004). There is evidence that the way ideas are presented to people enhances or inhibits open-mindedness. For example, if asked to list arguments for and against an issue, rather than just arguments representing one’s view, respondents would produce a greater number of arguments (Peterson and Seligman, 2004). We propose that applying such interventions to farmers may bring about substantial changes. Nevertheless, as extension services may be significant in technology implementation, future research should focus on the impact and effectiveness of new extension approaches based on increasing and utilizing CS.

Finally, the study further develops the emergent field of positive sustainability by empirically substantiating a theoretical approach. We trust this novel perspective to motivate future empirical research that would test this theoretical model within diverse farming communities worldwide. Additional local and international research should seek further empirical evidence for the connection between development studies and positive psychology. The adoption of sustainable agriculture technologies holds a promise for a sustainable future, and its promotion should have priority with scholars and policymakers alike.

Declarations

Author contribution statement

S. Bukchin, D. Kerret: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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Upadhyay, B., Samad, M., Giordano, M., 2005. Livelihoods and Gender Roles in Drip-Irrigation Technology: A Case of Nepal, 87. IWMI.

Waha, K., Müller, C., Bondeau, A., Dietrich, J., Kurukulasuriya, P., Heinke, J., Lotze-Campen, H., 2013. Adaptation to climate change through the choice of cropping system and sowing date in sub-Saharan Africa. Global Environ. Change 23 (1), 130–143.

Wane, A., D’alessandro, S., Fall, A.A., Grey, G., Simpkin, S., 2015. Senegal Agricultural Sector Risk Assessment.

Wood, S.A., Jina, A.S., Jain, M., Kristjanson, P., DeFries, R.S., 2014. Smallholder farmer cropping decisions related to climate variability across multiple regions. Global Environ. Change 25, 163–172.

Zenasni, F., Besançon, M., Lubart, T., 2008. Creativity and tolerance of ambiguity: an empirical study. J. Creativ. Behav. 42 (1), 61–73.

Zwarteveen, M., Neupane, N., 1995. Gender aspects of irrigation management: the Chhattis Mauja irrigation system in Nepal. Asia Pac. J. Rural Dev. 5 (1), 1–26.