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Determinants of household adoption of solar energy technology in Seychelles in a context of 100% access to electricity

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Abstract
Seychelles is among four countries in the African continent with 100% access to electricity, of which over 90% of the energy is generated from fossil fuels. The energy transition is a crucial enabler of sustainable development and climate resilience. Therefore, this study seeks to understand the determinants of solar PV uptake based on a stratified random sample of 130 households on Mahe Island, Seychelles. We applied logistic regression and descriptive statistics to analyze the driving factors of a household decision regarding the adoption of a solar PV system. Results indicated that access to credit and monthly household income influenced the adoption of solar PV systems at the 1% significance level. Independent variables such as gender, age, and education of household heads, including family size that were significant in other studies, were not significant in the current study. Cost-saving (100%), energy security (91.7%), and environmentally friendly perceptions (76.7%), and access to loans (56.7%), were chief among the motivational drivers of the 60 households that had adopted solar PV systems. Whereas, for the non-adopters, the four most essential barriers cited were cheap electricity (82.9%), high initial cost (65.7%), existing loans (52.9%), and long payback time (40.0%). For the communal approach to solar PV systems in Seychelles to be successful, the adoption barriers that occur at the level of households should be considered.

Keywords Flexible pay · Household · Solar photovoltaic · Energy access · Incentives · Seychelles

1 Introduction

Energy generated from fossil fuel sources has witnessed a remarkable increase with a 50% projected growth rate globally between 2019 and 2050 under the business as usual scenario [1]. An increase in energy demand is driven by multiple factors, including population growth, higher standards of living, changes in consumer behavior, economic development, and industrialization [2]. In 2020, 9% of all energy generated in Africa came from renewable sources with a firm reliance (6.8%) on hydropower, while over 80% of electricity generated across the continent is from fossil fuels [3]. Development agencies promote a transition from fossil fuels to renewable energy sources since energy-related carbon dioxide emissions represent two-thirds of all greenhouse gases [4]. As such, the role of renewable energy in global energy transformation is at the core of the Paris Agreement and the 2030 Agenda for Sustainable Development [5]. Several studies have shown that access to reliable energy is a key driver that can contribute to the achievement of other SDGs [4, 6–10].

Sustainable Development Goal 7 calls for ensuring access to affordable, reliable, sustainable, and modern energy for everyone [11]. Yet, at the current rate of progress, less than 60% of the population in Africa will have access to electricity

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by 2030, making it challenging to address extreme poverty while concomitantly pursuing other SDGs [12, 13]. For Seychelles, with 100% access to electricity, of which over 90% is generated from fossil fuels [14], fluctuations in oil prices can substantially impede sustainable development objectives [15, 16], and by extension, emission reduction. Therefore, investment in renewable energy is a win–win for emission reduction while ensuring the attainment of the SDGs. Aware of these opportunities, the Government of Seychelles (GoS) began to pursue a wider diffusion and dissemination of renewable energy [17]. For example, through the Wind Farm Project, the Public Utilities Corporation (PUC) installed eight wind turbines in 2013 with a 6 MW capacity, and another 3.5 MW capacity was achieved through four solar power projects in Seychelles [18, 19]. However, clean energy comprises just 5% of the energy mix in Seychelles, with an additional 5% contribution expected when the construction of the ongoing 5-MW floating solar power plant on Mahe Island is completed and operational [19].

Furthermore, Seychelles Updated Nationally Determined Contribution is committed to achieving a renewable energy target of 15% by 2030 [20]. Achieving the NDC targets for renewable energy will require a joint effort from the Government and the population. Therefore, householders can significantly contribute to the solar PV system uptake, and the GoS have introduced some policies and financial incentives for over a decade. The incentives include exempting value-added tax (VAT) on importing renewable energy technologies, a rebate scheme for PV systems, and access to low-interest-rate loans on PV technology [21]. Despite these attractive incentives, the PV adoption rate is relatively low compared to over 30,000 households in Seychelles [22], with 406 homes that adopted solar PV systems between 2013 and 2021 [23].

Although studies have been conducted on the determinants of renewable energy technology adoption in Africa [12, 24–27] and other developing countries [13, 28], these case studies have occurred in settings where the majority of the population, especially those in the rural areas, lack access to electricity. However, studies on factors that influence the adoption of solar PV systems in a context of 100% access to electricity are lacking in Seychelles, Morocco, Egypt, and Tunisia, the four African countries in the category. Household adoption of solar PV systems is influenced by socio-cultural, economic, political, institutional, and techno-specific variables that may vary from country to country. Even with greater access to electricity, the share from renewable sources requires improvement with 37% and 31% for Morocco and Egypt, while Tunisia and Seychelles recorded a minuscule 6% and 5%, respectively, as of 2021 [3]. Therefore, this study addresses a critical knowledge gap on the determinants of household adoption of solar PV systems in Seychelles within a context of 100% access to electricity. A rigorous understanding of the underlying factors determining the adoption of solar energy technology within such a context can enhance policies and strategies that foster a transition from fossil fuels to renewable energy.

2 Drivers of solar PV adoption—literature review and theoretical perspective

Household adoption of solar energy technology does not occur by chance but is influenced by internal and external factors [13]. Internal factors are inherent to households and include socio-demographic characteristics (e.g., age, gender, household size, education, income, access to credit, etc.), technology awareness and intention of conserving energy, and external factors are related to cost, characteristics of the PV system, market system, institutions, and state policies [12]. Incentives provided through state policies have been identified in two previous studies as important drivers for the uptake of solar energy technology among householders [29, 30]. The Government of Seychelles has implemented several attractive policies and financial incentives to enhance household adoption of solar PV systems. A good example is the rebate scheme for rooftop PV systems. Under this scheme, commercial operators benefit from a 15% rebate of their total cost of purchase and installation of solar PV systems, whereas for householders, the refund is 25% [21].

The Seychelles Energy Efficiency and Renewable Energy Programme (SEEREP) is another financial incentive instituted by the GoS to promote the adoption of renewable energy technologies and energy conservation among households. This Programme facilitates access to low-interest loans from commercial banks and the Seychelles Credit Union with an interest rate of 5% annually within a 1–5 years loan period [21]. Under the SEEREP scheme, the customer would need to pay not more than 2.5% of the loan amount as a beneficiary contribution, and the standard loan processing fees will not be considered. The amount to be applied for by householders was increased from SCR 100,000 (equivalent to USD 7,400) in 2017 to SCR 150,000 (equal to USD 11,100) in 2019 due to associated expenses related to importation and installation of solar PV systems [21]. Incentives, especially regarding finances, significantly contribute to household uptake of solar PV. A study in Pakistan found that financial support by the government for installing small solar PV systems positively influenced householders' adoption decisions [13].

Therefore, the decision of households to adopt solar energy technology is influenced by an interplay of lifestyle choices, household socio-demographic, economic, and institutional factors, including awareness and access to information [12, 13, 28, 31]. A study on households that had adopted solar energy systems in rural Bangladesh showed a positive influence on household lifestyle, such as an increase in study time of children [32]. Benefits of a much better quality of life provided through reliable and clean energy sources influenced adoption in some instances—a view supported by Vasseur and Kemp [33]. However, the issue of context is essential given that Seychelles' case occurs in a scenario with 100% access to electricity, with a flexible payment arrangement in installments for monthly energy tariffs. Therefore, the determinants of household adoption of solar PV systems might not be the same compared to the trend observed in other developing countries and the African continent, which has the least access to electricity globally [34].

However, previous studies have shown that household income, age, gender, household size and education of household heads, access to credit, peer effects, and household ownership are essential factors that influence the adoption decision of solar PV systems [12, 13, 28, 31, 35, 36]. Household wealth can overcome the cost barrier and therefore demonstrate a direct relationship with the adoption of solar PV, given that householders with relatively higher income have greater purchasing power. Education, on the other hand, does not demonstrate a direct relationship since other factors beyond knowledge and awareness influence adoption decisions [13]. That notwithstanding, consumers are known to give more importance to cost than environmental concerns when deciding between solar PV adoption [37]. This study further explained that householders are interested in technology to reduce costs and save money rather than for environmental consciousness.

To sum it up, household decision-making and adoption of solar energy technology determinants include environmental/biophysical, economic, socio-demographic, institutional, and political determinants [29, 38]. All of these determinants have been grouped into four broad categories by another study as follows: (i) the perceived relative advantage of the technology, (ii) the complexity of the innovation, (iii) social influence, and (iv) knowledge of grants and costs [33]. This study argued that the differences between adopters and non-adopters are attributed to adopters valuing the benefits of solar energy more than non-adopters. Thus the perception of the household is a critical determinant of their technology adoption. Seychelles Energy Commission is implementing a project to create a financial vehicle for consumers to own PV systems through a communal approach. The PV democratization 2.0 project aims to increase access to solar PV to households who cannot afford a rooftop PV system, access a low-cost loan, or have a roof that is not conducive to installing a PV system. Therefore, the adoption decision goes beyond the awareness of the benefits provided by the solar PV system, and the current study seeks to understand these drivers, especially in 100% access to electricity.

3 Materials and methods

3.1 Data collection and sampling

The Seychelles Energy Commission (SEC) was the entry point for this study, during which a comprehensive list of householders that have adopted solar PV systems was provided. The total number stood at 406 adopters that occurred between 2013 and 2021 [23]. Additional information provided by the SEC related to the rebate scheme, loans for solar PV systems, awareness strategies to promote PV uptake, and the costs of purchase and installation of different PV capacities (C. Alexander, personal communication, January 16, 2020). A total of 75 households were selected from the 406 householders that have adopted solar PV. The selection process ensured that the authors chose a minimum of 20% of homes from the North, South, East, and West of Mahe Island. For the non-adopters, 75 householders were randomly selected in the same neighborhood as the adopters, totaling 150 households for the entire survey. This research was approved by the Research and Ethics Committee of the University of Seychelles. The survey were conducted according to established ethical guidelines, and informed consent obtained from the householders.

Seychelles has a population of 97,625, of which 85,462 reside on Mahe, the main granitic islands. An estimated 90% of the nation's population lives on Mahe Island [39], and Seychelles has 100% access to electricity [40]. The fieldwork for this study took place between January to March 2020. The data was collected from 150 households with a response rate of 86.7%, corresponding to 130 homes. Therefore, only the fully completed surveys without missing variables were used for empirical analysis. Data collection included a wide range of variables such as monthly household income, access to credit, savings, age, gender, and education of household heads, family size, peer effect, in addition to two qualitative questions on motivational drivers for the group of adopters, as well as, barriers for the non-adopters.

3.2 Empirical modeling of solar energy technology adoption

Given that the dependent variable for this study is dichotomous with "1" and "0" for both adopters and non-adopters of a solar PV system, the empirical model is based on the logit model. This model is the most suitable since alternative options that could have been applied, such as the ordinary least square (OLS), suffers from two significant limitations. Firstly, the fitted probabilities can be <0 or >1 and will generate values that violate the dichotomous arrangement. Secondly, the partial effect of an explanatory variable is constant [41]. Although the logit and probit models (standard binary models) generate similar predicted probabilities, the former is computationally easier to use and lends itself to a meaningful interpretation than the latter [42]. This view is supported by another study based on the logit model to analyze the determinants of household adoption of solar energy technology in rural Ethiopia [12].

The logit model assumes a logistic distribution function and uses the maximum likelihood estimation approach after transforming the response variable into a logit [43]. It measures the odds of household adoption of solar PV systems. After converting the dependent variable into the natural log of the odds (logit), the equation is presented as follows:

$$ln\left(\frac{P_i}{1-P_i}\right) = X_i\beta \tag{1}$$

$$P_i = \frac{e^{X_i\beta}}{1+e^{X_i\beta}} \tag{2}$$

where P_i is the probability of the event occurring and, in this case, a household that has adopted solar PV system, X_i stands for the explanatory variables applied in the model (i.e., age, gender, income, household size, education, household dependency ratio, savings and access to credit), e is the base of the natural logarithm, and β is the vector of the unknown parameters to be estimated in the model.

Guided by the estimation method applied in similar studies [12, 28, 43], the model can be formulated as follows:

$$P_i = \frac{1}{1+e^{X_i\beta}} \tag{3}$$

A dummy variable, Y, was used to identify whether each sampled household is a user or non-user of solar energy technology. Therefore, Y is the dichotomous dependent variable in which the value of "1" stands for households that have adopted solar energy technology while "0" indicates otherwise. Aside from the dummy dependent variable, X_i represents the independent variables that might affect the decision of householders to adopt solar PV systems (see Table 1 for a complete list of independent variables). The reduced form of the equation is as follows:

Table 1 Explanatory variables and their likely influence on household adoption of solar PV

Variable	Description	Expected sign
Access_credit	Household access to credit (1 = have access, 0 otherwise)	+
Savings_HH	Household has saved money (1 = yes, 0 otherwise)	+
Gender_HHH	Sex of the household head (1 = Male, 0 = Female)	±
Age_HHH	Age of household head (Year)	±
IncomeHH	Income of household (SCR)	+
Familysize	Number of family members (number)	±
Dependencyratio_HH	Household dependency ration	±
Adultmale	Number of family members that are adult male (number)	±
Adultfemale	Number of family members that are adult female (number)	±
Child < 15 years	Number of children under the age of 15 years (number)	±
Elder > 65 years	Number of elders above the age of 65 years (number)	±
Schoolingyears_HHH	Years of schooling of the household head (Years)	+

$$Y_i = log(odd(event)) = \log\left(\frac{prob(event)}{prob(nonevent)}\right) = \tag{4}$$

$$Y_i = \beta_0 + \sum_{i=1}^{n} X_i\beta + \varepsilon_i \tag{5}$$

where ε_i is the error term. The following section reviews the key determinants of household solar PV adoption based on relevant pieces of literature and in the context of Seychelles.

3.3 Determinants of household solar energy adoption

The review of literature sources above indicates that the empirical evidence is scarce, especially on determinants for household solar energy adoption in a developing country with 100% access to electricity. This section provides a brief explanation of factors presumed to influence this decision which is included in the empirical model alongside their theoretically anticipated effects. Table 1 shows the explanatory variables considered in the logistic regression model for investigating household solar energy adoption decisions.

All things being equal, household wealth is expected to positively affect the adoption of solar PV systems, given that not all households can afford the high initial cost. This proposition is particularly true for low-income countries, with most householders living in poverty [44]. However, household wealth could act as a double-edged sword and cannot always be assumed to influence solar PV system adoption. For example, while some studies have found a positive effect of household wealth as a contributing factor toward solar PV adoption [25, 29, 45], it has proven otherwise in some instances [46]. Household wealth goes beyond income and considers other productive assets such as landholdings, savings, and the number of cattle owned, as mentioned in previous studies [12, 25, 47]. Therefore, contextualization becomes even more relevant in the case of Seychelles, which provides free education and medical services to its citizens, in addition to a range of benefits for housing and unemployment [23].

Besides wealth, the model also controlled for household demographic factors such as household size, household dependency ratio, age, gender, education of household heads, household savings and access to credit, etc. Going by previous studies [12, 13], household size is expected to positively or negatively affect the adoption of solar PV systems. According to De Groote et al. [29], larger households are likely to adopt solar PV given that their share of income spent on electricity is expected to be more, and the contrary for homes with smaller sizes. Due to limited land for infrastructural development, family units with adult males and females, in most cases, building on available space on the family land is typical in Seychelles [23]. With the family unit arrangement that prevails in Seychelles, the household dependency ratio could not be ignored and was considered as one of the independent variables. Inspired by Hadley et al. [48], the household dependency ratio is calculated as follows: (household members aged 0 and 14 + those aged 65 years and above) divided by those between the ages of 15 and 64), and multiplied by 100. The assumption was that the higher the dependency ratio of the household, the less likely it can adopt solar PV and vice versa.

Regarding the gender of household heads, ecofeminism suggests that women are more active than men regarding environmental issues for various social, cultural, and biological reasons [49]. For instance, Akeyo et al. [50] found that renewable energy development is supported by about 90% of women compared to 60% of men. By contrast, another study showed that men were likelier to adopt new technologies than women [51]. Therefore, the gender of household heads could favor women or men in decision-making on solar PV adoption. Likewise, the age of household heads influences investment in solar PV, especially for the environmentally conscious young.

Household educational status is another driver of solar PV adoption. Educated household heads tend to acquire a greater awareness of the multiple benefits of a renewable energy source such as PV. However, mixed evidence exists regarding the effect of education on adoption decisions. While two studies found a positive impact of education on household solar panel adoption [24, 45], there wasn't any positive effect in another study [29]. In the case of low-income households, differences in educational status are an essential determinant of how people acquire and use the information on solar PV technology and its benefits. The less educated may lack awareness of such benefits. Therefore, the model controls household heads' education regarding the number of schooling years.

Lastly, the model controlled for a key institutional factor that affects household solar PV adoption. This factor is household access to credit, one of the programs implemented by the government of Seychelles to facilitate

householders to access loans with low-interest rates for rooftop PV in addition to a 25% rebate scheme [21]. Access to credit in the current study is based on a solar scheme that was implemented between 2014 and 2020 known as the Seychelles Energy Efficiency and Renewable Energy Programmme (SEEREP). The SEEREP was a subsised loan designed to help households and Small–Medium Enterprises (SMEs) access capital to make their house or businesses more energy efficient and invest in Renewable Energy Technologies (RET). Applicants can borrow up to SCR150,000 (1 SCR = 0.077 USD) at a low 5% interest rate over a period of 5 years. Loan above SCR 75,000 are subject to a personal contribution of 2.5% [21]. Theoretically, households with access to credit are expected to have a higher probability of adopting solar PV. This is because the high initial costs associated with purchasing and installing PV are a crucial challenge, especially for most low-income households [44]. To corroborate the views of institutional factors, financial support, subsidy, technical service support, and communication contributed to household adoption of PV in rural China [52].

4 Results and discussion

4.1 Descriptive statistics

The descriptive statistics showed that, of the 130 completed household surveys, 46.2% were adopters, while 53.8% were non-adopters of solar PV systems (Table 2). Regarding the gender of the household heads, the figure stood at 42.3% for males and 57.7% for females. However, the households that adopted solar PV had equal numbers of male and female heads of household, corresponding to 23.1% each. Regarding household access to credit, only 9.2% of the non-adopters had access to credit, while 44.6% did not (Table 2). On the other hand, 40.8% of adopters had access to credit, whereas a minuscule 5.4% didn't (Table 2). Access to credit within the context of the study is the ability of a household to be qualified to access finances directly from banks or to qualify for loans that the Seychelles Energy Commission facilitates for the purchase and installation of solar PV. Household savings was another variable that showed a similar credit access pattern. Only 10.8% of the non-adopters had savings in terms of finances compared to 41.5% of adopters. The summary statistics indicated a significant variation between the adopters and non-adopters regarding access to credit, savings, and monthly household income (Table 2).

Education is among the variables that did not differ significantly between the two groups. One possible explanation could be linked to the fact that education in Seychelles is highly subsidized by the Government of Seychelles and is provided free of charge to all Seychellois up to advanced level [23]. In addition, the Agency for National Human Resource Development (ANHRD), Seychelles, offers several funding instruments for Seychellois to undertake graduate and post-graduate studies within the country and abroad. Historically, there hasn't been any cultural role that imposes restrictions on who acquires education, thereby allowing both males and females equal access to education [23]. The age, gender, and education of household heads, family size, and dependency ratios were insignificant and did not influence the adoption of solar PV. However, it is difficult to infer causality as the effect of other factors which are not controlled might affect the results. This is important for the current study as it occurs in a context with 100% access to electricity.

Table 2 Descriptive statistics of variables and mean differences for adopters and non-adopters. Source: Field Survey, 2020

Variables	Whole sample		Adopters		Non-adopters	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
AdoptsolarPV	0.46	0.500				
Credit	0.50	0.502	0.88	0.324	0.17	0.380
Savings_HH	0.52	0.501	0.90	0.303	0.20	0.403
Gender_HHH	1.58	0.496	1.50	0.504	1.64	0.483
Age_HHH	49.04	13.061	48.50	13.117	49.50	13.090
Income_HH	51361.54	25953.97	65750.00	25448.27	39028.57	19268.30
Family size	5.58	1.579	5.75	1.663	5.43	1.50
Dependency ratio_HH	60.51	69.333	50.12	63.171	69.43	73.49
Schooling years_HHH	17.84	4.011	18.32	3.244	17.43	4.55

4.2 Regression results

Table 3 presents the results of the logistic regression model on the determinants of household solar PV adoption based on seven independent variables (access to credit, gender, age, monthly household income, family size, household dependency ratio, and the schooling years of the household heads). Household savings was excluded from the final regression model due to multicollinearity. The complete model containing all predictors was statistically significant, χ^2 (8, N = 130) = 113.63, $p < 0.01$, indicating that the model could distinguish between adopters and non-adopters of solar PV. Therefore, the model as a whole explained between 58.3% (Cox and Snell R Squared) and 77.9% (Nagelkerke R Squared) of the variance in solar PV adoption status and correctly classified 89.2% of cases.

As shown in Table 3, only three independent variables made a unique statistically significant contribution to the model. Access to credit and household savings did influence the adoption of solar PV at the 1% ($p < 0.01$) level of significance, while monthly household income did so at the 5% ($p < 0.01$) level of significance (Table 3). On the other hand, five independent variables were insignificant, including age, gender, education of household heads, family size, and household dependency ratios.

4.2.1 Household access to credit

In the current study, household access to credit for PV technology adoption was found to have a positive and significant influence at the 1% level of significance ($p < 0.01$). The odds ratio of households with access to PV loans was higher by a factor of 16.78 compared to those without access (Table 3). The Financial Rebate Scheme for grid-connected rooftop photovoltaic systems was launched as a project in May 2014 and ended in March 2022. This project was a collaboration between the Government of Seychelles, the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF). The Financial Rebate Scheme provided a 35% financial rebate on any PV system up to a 3 kilowatt peak (kWp) for Seychellois households [21]. However, information gathered during the survey showed that households with existing loans such as car and housing loans could not access loans through this scheme.

4.2.2 Income of household

Results showed that household income positively affected solar PV adoption and is statistically significant at the 10% level (Table 3). An increase in the monthly income of householders by 1 Seychellois Rupee results in an increase in the likelihood of household solar PV adoption by a factor of 1 (Table 3). As the income of householders increases, the probability of taking up solar PV increases because it creates a better financial ability to either pay or secure a loan for the purchase and installation of solar energy technology. Our findings are consistent with other studies in which an increase in the likelihood of household solar energy technology adoption is influenced by the rise in household income [12, 24, 25, 29, 53]. In other words, the higher the household income, the higher the household purchasing power is, of which some households might shift towards using solar energy technology. Therefore, policies that augment household income or enhance purchasing power may be a viable strategy to promote solar energy technology adoption among householders.

Table 3 Logistic regression of solar energy technology adoption

		B	S.E	Wald	df	Sig	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	Credit(1)	2.820	0.745	14.337	1	.000***	16.776	3.897	72.211
	Gender_HHH(1)	0.516	0.712	0.525	1	0.469	1.676	0.415	6.768
	Age	−0.003	0.030	0.013	1	0.910	0.997	0.939	1.058
	Income	0.000	0.000	6.309	1	0.012***	1.000	1.000	1.000
	Familysize	0.128	0.276	0.216	1	0.642	1.137	0.662	1.953
	Dependency	−0.002	0.006	0.080	1	0.777	0.998	0.987	1.010
	Schooling	−0.085	0.099	0.741	1	0.389	0.918	0.756	1.115
	Constant	1.166	2.596	0.202	1	0.653	3.210		

[a]Variable(s) entered on step 1: Credit, gender_HHH, age, income, Familysize, dependency, schooling

[b]*, **, and *** indicate significance at the 0.1, 0.05, and 0.01, respectively

This is because household income has been identified as one of the main determinants that affect household solar PV adoption [12].

4.2.3 Household head education level

The current study considered the number of schooling years to assess household heads' educational levels. Education improves household awareness and expands their employment opportunity; thus, higher education attainment by the household heads is expected to increase the likelihood of solar PV. However, the independent educational variable was not significant, meaning education does not positively affect the adoption of solar PV. Except for a study from Kenya which found a weak positive effect of higher education on household adoption of solar PV [54], other studies indicated that highly educated people are more willing to pay for renewable energy [12, 24, 25, 55, 56].

According to these studies, an increase in the educational levels of the household heads will also lead to an increase in the level of awareness of the household regarding clean energy services. While this may be true for these case study countries, the context of Seychelles as a Small Island Developing State (SIDS) is different and should be interpreted cautiously. For example, Etongo [23] found that information quickly circulates through formal and informal channels, raising awareness, which is an essential part of education. This study further indicated that adult literacy in Seychelles stands at 96% in addition to free education provided to all Seychellois in public schools up to advance level. Therefore, the level of education and awareness on environmental issues is higher in Seychelles compared to other developing countries and the African continent.

4.2.4 Household size and dependency ratio

Household size and household dependency ratio did not have a significant and positive influence on solar PV adoption (Table 3). Although these factors were not significant, results showed that as family size increase by one person, the odds ratio of householders to adopt solar PV increases by a factor of 1.14 (Table 3), with "all other things being equal" (Ceteris paribus). A flexible payment arrangement of electricity tariffs is operational in Seychelles to ensure that even the relatively poorer households can afford it. Our findings are contrary to two other studies, which found that larger households tend to choose solar energy technology for domestic purposes compared to smaller family sizes [12, 24].

4.2.5 Gender and age of household head

Regarding gender and age of household heads, our results showed that these variables had no significant and positive influence on the adoption of solar PV (Table 3). Historically, there hasn't been any cultural role that imposes restrictions as to who acquires education or performs domestic duties based on gender in Seychelles. However, Seychelles is a matrifocal society in which women play a more significant role in decision-making for the family or household [23]. However, a systematic review across sub-Saharan Africa indicated that the adoption of solar energy technologies might reproduce the structures that determine power and resource allocation at the local level, such as control over resources, gendered division of labor, and gendered domestic space, with implications for women who have to perform household chores [57]. Furthermore, previous studies found that women are more willing to pay or support renewable energy technologies because it will ease their burden on the long hours spent gathering fuel wood and also reduce their exposure to indoor air pollution [12, 50, 53]. The situation in the case of Seychelles is also unique because it's more about decision-making in a context where all households already have access to electricity—a contrary scenario to what prevails in most developing countries and Africa in particular.

On the other hand, the age of household heads wasn't significant and did not positively affect solar PV adoption in the current study. This implies that the adoption of solar PV in the Seychelles case is not influenced by age—an independent variable that is significant in other studies. For example, two previous studies found that younger people are more willing to pay for renewable energy because of higher awareness of the environmental benefits it does provide [29, 55]. In contrast, another study argued that older heads of households might be wealthier as they own more productive resources (e.g., land) and are likely to invest in renewable energy technologies [12]. Such findings reinforce that context is essential, given that the youthful or elderly age group might influence the adoption-decision of solar PV. It becomes more interesting in the case of the Seychelles case study because the country is among the four African countries with 100% access to electricity as of 2020 [40]. Therefore, the challenge here isn't about access to electricity but how to transit

from the use of electricity predominantly generated from fossil fuel to renewable sources such as solar energy technology. Therefore, other factors might influence such a transition besides the age of household heads.

4.3 Motivations and barriers toward solar PV adoption

Qualitative questions were asked to gain insights into the drivers and barriers to adopting solar PV. For the 60 households that had adopted solar PV, the three most important reasons cited as motivational drivers were cost-saving, energy security, and environment friendly, which correspond to 100%, 91.7%, and 76.7%, respectively (Fig. 1). These findings are consistent with previous studies, which found that the motivation for PV adoption was generally linked to socio-economic and environmental factors [13, 58], primarily by the desire for energy security [59, 60], energy autonomy [13], cost savings from reduced electricity bills [61], and peer effect [62–64]. Peer effects, for example, are essential for raising interest and speeding the decision time between considering and adopting with direct contact with non-adopters, with adopters having the potential to shorten decision time [65]. In the case of Seychelles as a Small Island Developing States (SIDS) case, community interaction is relatively higher, and information quickly circulates among the population through formal and informal channels with community members easily influenced by others or their neighbors.

Several barriers that acted as hindrances were mentioned by the 70 surveyed households that did not adopt solar PV. Chief among the reasons cited included cheap electricity (82.9%), the high initial cost for purchase and installation (65.7), existing loans (52.9%), and another 40% who mentioned long payback time as a barrier (Fig. 2). Electricity tariffs for domestic customers as of June 2020 as set by the Public Utilities Corporation (PUC) are as follows: 1.57 SCR (0–200 KWh), 1.86 SCR (201–300 KWh), 3.5 SCR (301–400 KWh), 3.9 SCR (401–600 KWh), and 4.55 SCR (exceeding 600 KWh). It should be noted that 1 SCR is equivalent to $ 0.07 per the exchange rate on June 1, 2022. Households are allowed a flexible payment arrangement in which those householders who cannot afford to pay the total amount of their monthly tariffs can pay in installments. This provides an opportunity for households facing periodic financial constraints or those whose household income can only allow for installment payments. This might be the plausible reason why electricity is considered cheap in Seychelles, and most householders that were non-adopters were skeptical about the benefits of adopting solar energy technology—a view supported by several other studies [13, 35, 59, 60, 66].

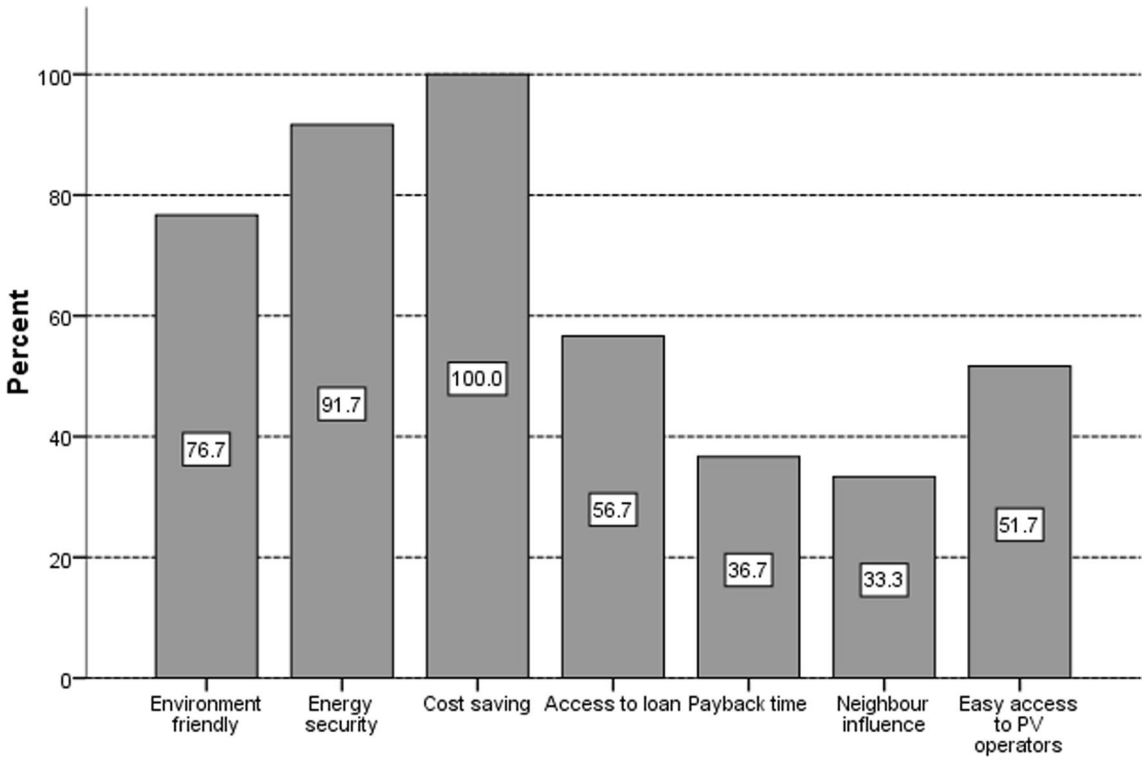

Fig. 1 Motivations for PV uptake among the 60 surveyed householders that had adopted PV. Note: multiple response question (% > 100)

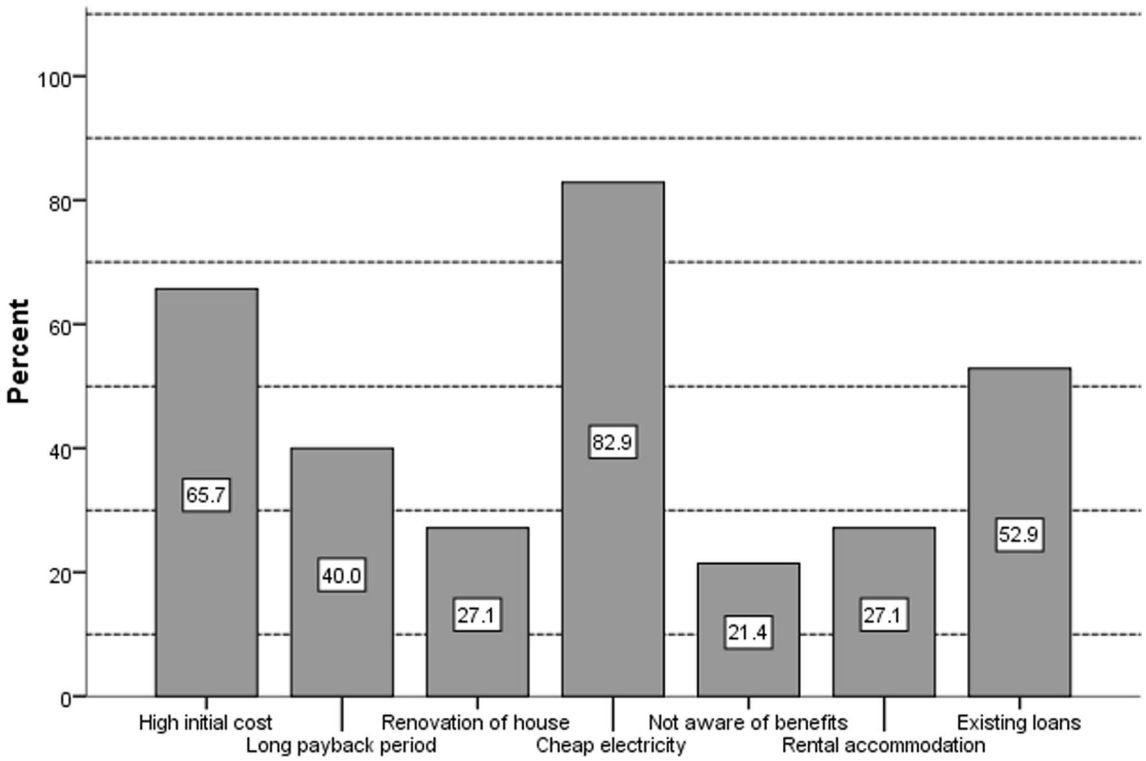

Fig. 2 Reasons cited as barriers among the 70 surveyed households that didn't adopt PV. Note: multiple response question (% > 100)

Aside from affordable electricity, high initial cost (65.7%) was another barrier ranked as the second-highest given that high capital investment is needed to purchase and install solar energy technology. In the case of Seychelles, the Government has put in place several policies and financial incentives to reduce the initial costs of purchasing PV and facilitate its uptake among householders. These incentives include no Value Added Tax (VAT) on the importation of renewable energy technologies; households can achieve 100% renewable energy and a 35% financial rebate on PV systems ≥ 3 kilowatts [17, 67]. With all these incentives, the high initial cost remains a challenge, but not as compared to other developing countries that lack such incentives as indicated by other studies [13, 59, 60, 68].

Another barrier among the non-adopters was existing loans corresponding to 52.9% (Fig. 2). According to these households, they had existing loans for cars and housing and could not qualify for another loan. Aside from existing loans, 40% of non-adopter households mentioned a long payback period as another barrier. Based on information from the Seychelles Energy Commission (SEC), most households often purchase between 3 and 5KW solar PV capacity. The payback time of the loan is usually between 3 and 4 years, with the costs of purchase and installation ranging from $ 8,500–$ 11,000 for a 5KW capacity [67]. Households will have to pay a monthly average of $ 205 over 48 months. Although the capacity and costs of solar PV weren't mentioned, Karjalainen and Ahvenniemi [66] reported that the payback period for solar home systems (SHS) in Finland ranges between 15 and 25 years. Other studies indicated that the long payback time might deter older potential adopters because future electricity pricing is unknown [60, 69].

5 Conclusion

Like other SIDS, Seychelles faces extremely high and fluctuating power costs resulting from dependency on fossil fuels for power generation. The current record high surges in oil prices, driven by shortages in Asia and the recent Russian-Ukraine conflict, leaves SIDS, like Seychelles, extremely vulnerable to price volatility and the risk of energy insecurity. Any fluctuation in crude oil prices is likely to pose a significant threat to economic development. However, renewable energy, especially solar PV, has much potential in Seychelles and can significantly contribute to energy security and sustainable development. Several policy and financial incentives have been put in place by the Government of Seychelles to enhance the adoption of solar energy technology. This study sets out to understand the determinants of solar PV

adoption in addition to motivational drivers and barriers among adopters and non-adopters. The regression results reveal that household access to credit and monthly income had a positive and significant effect on solar PV adoption. Specifically, access to credit and monthly household income did influence the adoption of solar PV at the 1% ($p < 0.001$) level of significance. These two variables strongly influenced the current study's adoption of solar energy technology.

Factors such as gender, education, and age of the household heads, in addition to family size and household dependency ratio, which were found to be significant determinants in other studies, proved the contrary in ours and were not significant. The uniqueness of Seychelles is highlighted here, given that it is among the four countries in the African continent with 100% access to electricity. Aside from being a SIDS, the context in Seychelles is different as the country gained the "high income" status in 2015. As such, the determinants of solar energy technology adoption are likely to deviate from the norm that prevails in most African countries, the majority of which reside in the rural area with limited access to electricity or are primarily dependent on traditional energy sources such as kerosene.

However, for the householder that had adopted solar energy technology, the reasons for their motivation were similar to other studies. The most important were cost-saving (100%), energy security (91.7%), environment friendly (76.7%), and access to loans (56.7%). On the other hand, the barriers cited by the non-adopters included cheap electricity (82.9%), the high initial cost of solar energy technology (65.7%), existing loans (52.9%), and a long payback period (40.0%). This study also found that, despite the population's awareness of solar energy technology, several factors had an influence, especially among non-adopters. All households have access to electricity and can afford their monthly tariff, which is much easier with a flexible payment arrangement in installments. A people-centered energy transition is underway in Seychelles, led by the Seychelles Energy Commission, within the framework of the PV democratization 2.0 project. This project will identify larger rooftops in which householders will jointly finance solar PV to benefit from renewable energy. Therefore, we recommend that the barriers hindering householders from adopting solar PV should be considered if the proposed communal approach plans to succeed.

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Author contributions The topic of the research was formulated by DE. The questionnaires were designed by DE and HN. Both DE and HN participated in the data collection. Data cleaning, analysis and the writing of the first draft was done by DE who also edited the first draft to produce the final version of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials The datasets generated during and/or analyzed during this study are not publicly available due to request of some respondents not to share their data publicly without reasonable permission. Hence, data will be available from the corresponding author on reasonable request and respondents' permission.

Declarations

Ethics approval and consent to participate The research was approved by the Research and Ethics Committee of the University of Seychelles, Republic of Seychelles. All the householders agreed for their data to be used for the purposes of research.

Competing interests Both authors declare no competing interests.

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