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INFLUENCE OF TECHNOLOGY ATTRIBUTES ON THE ADOPTION OF CONCENTRATED SOLAR TECHNOLOGY BY TEA FACTORIES RUN BY KTDA IN KENYA

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Abstract
The general objective of this study was to find out the effects of Concentrated Solar Power technology (CSPT) attributes on the adoption of CSPT by the Kenyan tea factories run by KTDA. Specifically the study investigated the effect of cost effectiveness, ease of installation, less health hazards, twenty four hour availability, acceptable heat range, minimize carbon emissions and triability attributes on the adoption of CSPT by tea factories managed by KTDA. The target populations was all factory unit managers of the 66 tea factories under the management of KTDA. The study was a cross-sectional survey taking a quantitative approach with descriptive and inferential statistical outcomes. Data collection was done using a structured questionnaire and a binary logistic regression model was used to analyse the data. Six specific attributes of CSPT (cost effectiveness, less health hazards, twenty four hour availability, acceptable heat range, minimize carbon emissions and triability) were found to have a positive relationship with adoption of CSPT. However ease of installation was found to be insignificant.

Keywords: Solar technology, installation, factory

BACKGROUND

The Kenyan tea sub-sector is one of the industries in Kenya with a significant need for process heat. Its energy requirement is in the temperature range of 60-80^{o}C (Rawlins & Ashcroft, 2013). The Kenya Tea Development Agency (KTDA) is mandated to manage 55 Kenyan tea owned by small scale farmers. In 2011, thirty six (36) of the companies ran by KTDA complained of rising fuel costs as a key threat to their organizations (Rawlins & Ashcroft, 2013). Almost all of the factories were using fuel wood as their basic source of heat energy, with the average tea factory using 20,000 cubic meters of firewood annually, which equals to about 60,000 trees. However, wood supply was declining as trees and forests got depleted. Prices of wood were also rising. This scenario triggered plans by thirty four (34) of the companies to plan to plant their own trees. They identified eucalyptus trees as a viable tree to be grown in plantations on the factories land as a self-reliant and sustainable source of wood fuel. This was to be attained by the year 2015.

This initiative was, however, faced by the challenge of inadequate land for sustainable wood production for the increasing demand of heat energy.

In the same period seventeen (17) factories were reported to be using fuel oil for heat generation and were reported to have used 3.6million litres of oil in 2011, which resulted in CO_2 emissions of approximately 14 ktCO_2 (Rawlins & Ashcroft, 2013) . These factories complained of rising oil prices, and were reported to have decided to change from using fuel oil as their heat energy source.

A study conducted in Kenya in 2013 by Carbon Trust reported the viability of Concentrating Solar Power Technology (CSPT) in Kenya (Rawlins & Ashcroft, 2013). This study particularly singled out the tea industry as a high potential beneficiary of CSPT. It found the tea factories could replace 30% of their energy requirement by taking up CSPT. CSPT facilities use mirrors to focus sunlight on a receiver, which receives, transforms and transfers the sun energy to a heat transfer fluid which in-turn supplies heat for direct application in an industrial process. (IEA-ETSAP & IRENA 2015).

Compared to use of fossil oil and fuel wood, CSPT leverages climate change mitigation in the form of reduction of carbon emissions from the factories (Rawlins & Ashcroft, 2013). It also improves energy security by replacing the depleting forest resources, and would help the factories save about thirty percent (30%) of their heat energy costs. Beyond this it would help reduce deforestation in the country and minimize health hazards caused by use of oil and wood in the factories. Even though solar heat technologies have exhibited a strong technical potential, and high promise for economic benefits for industry processes, their adoption has been very low (IEA-ETSAP & IRENA, 2015).

Due to CSPT potential, several newly industrializing countries have moved fast to embrace the technology. India has made great efforts for a strong CSPT sector, utilizing the country's good solar insolation (Hu and Wu, 2013). Other countries in which the technology is peaking up fast are South Africa, Saudia Arabia, Qatar and Morocco just to mention a few.

Considering the Kenya solar energy resource estimated at 4 to 6 kWh per square meter per day of solar isolation, the CSPT has been cited as a viable and sustainable source of heat energy for the country. A prototype parabolic trough solar concentrator for steam Production developed at Jomo Kenyatta University of Agriculture and Technology (JKUAT) generated a maximum temperature of steam of 248.3^oC while average temperature of steam produced was 150^oC (Kawira et al., 2012). These results obtained show that production of power using the sun flux is a viable undertaking in Kenya.

Despite the recommendations for use of CSPT in the tea sector in Kenya tea factories, by 2013 there was no evidence of any installed facility of the technology among the tea factories (Rawlins & Ashcroft, 2013).

Problem Statement

Energy is a crucial input for tea manufacture and energy costs constitute thirty percent (30%) of the total tea processing cost. Over 90% of tea factory energy requirements are for process heat used in withering and drying. Kenya tea factories are faced with the challenge of identifying a sustainable source of process heat energy. The wood and oil sources they have been using are not sustainable due to their high costs, depletion of natural resources and their negative impact on the environment. This challenge threatens future survival of the tea industry, Kenya foreign exchange earnings and the earnings and livelihood of the 600,000 small scale tea farmers, whose 80% income is from tea.

CSPT has been recommended as an alternative source of process heat energy for the industry. This source would be cheaper, more reliable, more environmental friendly and would secure survival of the industry and by extension the livelihood of the farmers. However, despite the promising qualities and potential benefits of CSPT, by 2013 the technology had not been adopted by any of the 66 tea factories under KTDA. This study sought to find out the extent to which the attributes of CSPT can be used to influence the adoption of CSPT by the tea factories managed by KTDA in Kenya.

Objectives of the Study

The general objective of the study was to analyse the effect of CSPT attributes on the adoption of CSPT by the KTDA run tea factories in Kenya.

Specific objectives

i) To analyse the effect of cost effectiveness attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
ii) To analyse the effect of ease of installation attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
iii) To analyse the effect of less health hazard attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
iv) To analyse the effect of twenty four availability attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
v) To analyse the effect of acceptable heat range attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
vi) To analyse the effect of minimize carbon emissions attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.
vii) To analyse the effect of triability attribute of CSPT on the adoption of CSPT by the KTDA run tea factories in Kenya.

Research Hypotheses

This study was guided by the following null hypotheses.

$H_0$8: CSPT attributes do not have a significant combined effect on the likelihood of the adoption of CSPT by the KTDA run tea factories in Kenya.

$H_0$1: There is no significant relationship between cost effectiveness attribute of CSPT and adoption of CSPT among the Kenyan tea factories run by KTDA.

$H_0$2: There is no significant relationship between ease of installation attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya.

$H_0$3: There is no significant relationship between less health hazards attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya.

$H_0$4: There is no significant relationship between twenty four hour availability attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya.

$H_0$5: There is no significant relationship between acceptable heat range attribute of CSPT and adoption of CSPT technologies by the KTDA run tea factories in Kenya.

$H_0$6: There is no significant relationship between minimize carbon emissions attribute of CSPT and adoption of CSPT technologies by the KTDA run tea factories in Kenya.

$H_0$7: There is no significant relationship between triability attribute of CSPT and adoption of CSPT technologies by the KTDA run tea factories in Kenya.

Theoretical framework

Rogers Theory on Diffusion of Innovation

The study was based on Everett M. Rogers' new technology diffusion model. Everett M. Rogers is largely famous for inventing the diffusion of innovation theory which he developed after his research on how farmers take up new agricultural innovations (Shoeb, 2014). Rogers explained that diffusion is a social process in which adoption of a technology starts slowly, followed by rapid adoption and ending with slow adoption a product matures and new innovations emerge.

As cited in (Sahin, 2006) Rogers defined innovation as an idea, process, or practice that is considered as novel by individuals or groups or organizations. He claimed that uncertainty about new innovations is a major hindrance to the adoption of innovations. This is because the consequences of using an innovation may create uncertainty. Consequences refer to new experiences that an individual or a social system are exposed to as a result of adopting an innovation. Therefore, to minimize this uncertainty before adoption of a new technology, individuals or organizations should be made aware of the advantages and disadvantages of the new technology so as to prepare them for its consequences. He also identified five characteristics of new innovations that are useful in minimizing uncertainty about an innovation thereby increasing the chances of its adoption. These were relative advantage of the innovation, compatibility with what is in use, its complexity, whether it is trialble, and observability. Relative advantage is the extent to which a new technology is seen as being better than the innovation it precedes (Sahin, 2006). Cost advantage, profitability and social status of innovations are examples of aspects of relative advantage.

Compatibility of a new technology refers to the extent to which it is perceived to be conforming to the current values, experiences from the past, and the needs of a potential adopter (Shoeb, 2014; Sahin, 2006). When a technology is seen to conform to the needs of an individual, its likely to reduce uncertainty which will in-turn raise the rate of adoption of an innovation. The name of an innovation is a key factor in attaining compatibility. The name of a new technology should have a clear meaning to the potential adopter, and this may spur an adoption decision. Complexity of a new technology was the other attribute cited by Rogers. This is the extent to which the technology is seen to be difficult to understand and use. He finally stated that complexity and adoption have an inverse relationship, and that high complexity of a new technology is a major hindrance to its adoption.

The other attribute was Trialability. This refers to the extent to which a new technology may be tried before adoption on a limited basis (Shoeb, 2014; Sahin, 2006). The more an innovation is triable, the more likely it is for it to be adopted. Finally was the observability attribute. Rogers explained observability as the extent to which the outcomes of a new innovation are evident to all. He concluded by citing role modelling and peer observations as important motivational factors in enhancing adoption and diffusion of new technologies (Sahin, 2006).

This study focussed on CSPT as a new innovation in process heat generation in industries. The above described characteristics of a new technology were used as the potential predictor variables for the adoption of the new technology, CSPT, by tea factories run by KTDA in Kenya. A situational analysis clarified seven attributes of CSPT for the study. These were cost effectiveness, ease of installation, less health hazards, twenty four hour availability, acceptable heat range, minimize carbon emissions and triability.

Empirical Literature Review

As articulated in Rogers diffusion theory reviewed earlier, an innovations important attributes are relative advantage, compatibility, complexity, triability, and observability. These attributes have been showcased in many projects through awareness campaigns and demonstrations. In the project, Energy Conservation in Small Sector Tea Processing Units in South India, these attributes were emphasized in a project website, and in about 100 one-on-one meetings held between tea factory owners and experts (Ocampo & Maithel, 2012). Beyond these, 30 demonstration projects were conducted. Further, liaison with energy equipment manufacturers was conducted to customize equipment for capacities required for the tea sector. This led to the acceptance of the suppliers as 'value-adding energy service providers' rather than just 'salesmen of equipment'. The outcome was that a total of 114 tea factories adopted the new technologies.

In an on-going project, Market Development & Promotion of Solar Concentrators for Process Heat Applications in India, one of the objectives of the project was to promote enhanced understanding of CSH technologies and their applications. The attributes were mainly exhibited through demonstration. Component 3 in the implementation of this project was pilot demonstration of CSH technologies for various applications (Akker & Aggarwal, 2015). A number of activities were lined up for the purpose of showcasing the viability of the CSH technologies. These were a website on CSTs, monthly newsletters and publications, development of case studies & success stories, training manuals for installers & manufacturers/suppliers, and a handbook on CSTs. Further, a technology assessment and performance evaluation is done of existing projects (Singhal, 2015). Reports on the evaluation aid policy makers identify salient features and limitations of CSTs when coming up with CSTs adoption strategies. This is work in progress and the outcomes have not been documented as yet.

Other studies have highlighted the pole position of an innovations attributes in influencing adoption decision. One of this studies investigated the role of attributes in explaining adoption of the interbank mobile payment service in an Indian context (Kapoor, Yogesh, & Michael, 2013). The study examined the role of innovation attributes in the adoption of interbank mobile service among 330 respondents in Delhi, Kolkata, Mumbai, and Bangalore cities in India. The attributes investigated were as stipulated in Rogers' diffusion of innovation theory. These were relative advantage, compatibility, complexity, cost, triability and observability. The study found that relative advantage, compatibility, cost, complexity and triability had a significant influence on the adoption of the interbank mobile payment service. However, observability attribute was found to have a poor relationship with adoption of interbank mobile payment service.

Another study was carried out in Nairobi, Kenya, investigating the role of technology characteristics in the adoption, rejection, and discontinued use of open source software for development (Tully, 2015). It focused on organizational adoption decisions of a new ICT platform known as Ushahidi, which was designed for collecting, aggregating and mapping information. The study was carried out among seven firms in Nairobi between December 2008 and July 2012. The study report indicates that the triability, observability, complexity and compatibility were key influencers of the adoption of Ushahidi platform. Beyond this, the study identified flexibility also as an important attribute to influence adoption.

There is another research study conducted on technological attributes that influence Radio Frequency Identification (RFID) technology adoption in logistics organizations (Sibayan, 2015).

The study investigated the technological factors considered when adopting RFID technology which is an innovation that give visibility for the management process in logistic organizations. The study was a review of cases from the past in various countries and was aimed at enhancing managers and leaders insight in adoption decision making concerning RFID technology in logistic organizations. It focussed on the compatibility, complexity and competence attributes and their influence on the adoption of RFID technology. The study found that compatibility, complexity and competence attributes influenced decision makers in adopting RFID technology. Further, it was reported that the effects of these attributes is mitigated when the innovation is made explicit to the all members of the organization, and that making the technology explicit minimizes uncertainty of the technology. Finally the study found out that the more educated and knowledgeable an organization is about the RFID innovation the more likely that the organization will adopt the technology.

Another study was conducted on the role of innovation attributes on adoption of renewable energy technologies. The study was carried out in Mexico with a purpose of analysing innovation attributes and their effect on the adoption of solar renewable energy innovations for town households (Pavel & Mercado, 2017). It was carried out among 291 town consumers. The study report indicate that compatibility was found to be a major influencer of adoption, but triability and relative advantage showed little influence on adoption of the solar technologies.

The above discussion on technological attributes and their influence on adoption of new technologies brings out five common attributes that may be crucial in enhancing adoption of new technologies. These are relative advantage, triability, compatibility, complexity and cost. However, the different studies have highlighted differing combinations of these attributes, and even in some rare cases, additional attributes in the name of flexibility and competence were introduced.

Conceptual framework

The study model is presented as a relationship between CSPT attributes and CSPT adoption. CSPT adoption is conceptualized as the dependent variable and CSPT attributes is conceptualized as the independent variable with seven covariates. The model is illustrated in Figure 1.

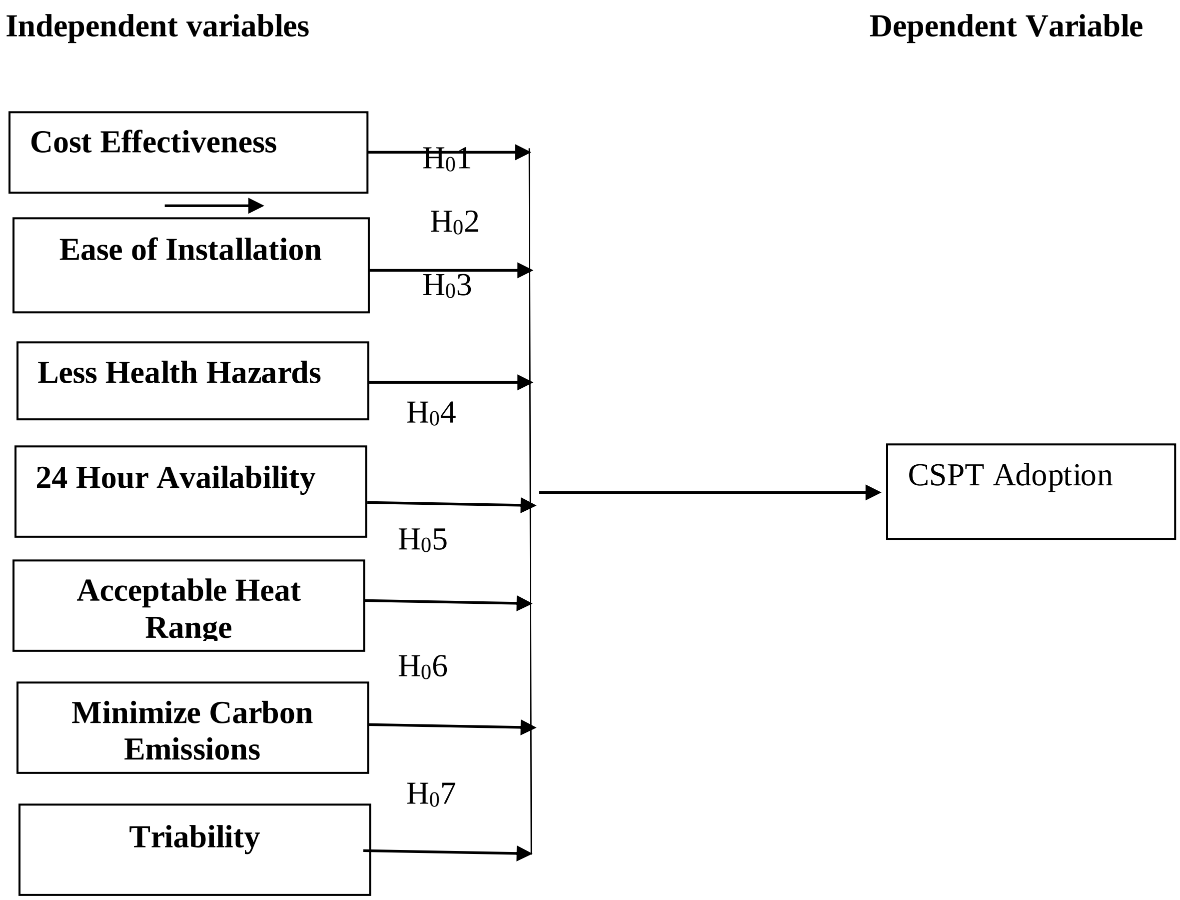

Figure 1. Conceptual Framework

METHODOLOGY

The study adopted a positivism philosophy which emphasizes working with observable social reality that end up in law-like generalizations (Saunders et al, 2009). This study was a cross-sectional survey serving descriptive and explanatory purposes. The survey was chosen as it enables the researcher to obtain data about practices, situations or views at one point in time through questionnaires or interviews, which can be examined to detect patterns of association (Bryman, 2012). The target population was the sixty six (66) tea factories in Kenya managed by KTDA. The 66 tea factories were spread out in 13 counties in the country. The target respondents of this study were the sixty six (66) unit managers of the tea factories run by KTDA.

The population size was considerably small and this suggested that a census was feasible and therefore no sampling was done. Census is an investigation of all the individual elements that make up a population (Zikmund et al, 2013). In this study, therefore, all the sixty six factories managed by KTDA were studied. Data collection for this study was by use of questionnaires.

Drop and Pick technique was applied with the target population. Data was analysed using descriptive statistics and inferential statistics obtained through logistic regression procedures. Firth penalized logistic regression model was selected for this study. The model offers solution to the problem of separation in logistic regression and small sample biases (Rahman & Sultsna, 2017; Eyduran 2008).

The proposed relationship between CSPT attributes and the adoption of CSPT was formulated using CSPT elements (cost effectiveness, health friendly, twenty four availability, easy to install, within acceptable heat range, minimize carbon emissions and triability) as covariates. The model for CSPT attributes was expressed as:

$$\text{Logist}f(\text{CSPT Adoption}) = \beta + \beta_1 X_1$$

$$= \boldsymbol{\beta + \beta_1 Costef + \beta_2 Hhzd + \beta_3 Twty4h + \beta_4 EasyIn + \beta_5 Hrange + \beta_6 MinCarb + \beta_7 Triabl} \quad \textbf{(i)}$$

Where β = is constant level of adoption not influenced by the regressor, X_1 = CSPT attributes, $\beta_1 \ldots\ldots \beta_7$ are regression parameters, while Costef, Hhzd, Twty4h, EasyIn, Hrange, MinCarb and Triabl are abbreviations for attributes of CSPT predictors cost effective, healthy, twenty four hours, easy to install, acceptable heat range, minimize carbon emissions and triability respectively.

RESULTS AND DISCUSSIONS

Adoption of CSPT by Tea Factories

The managers were investigated on the adoption of CSPT technology status of their factories. Adoption is a process involving five stages. These are knowledge, persuasion, decision, implementation and confirmation stages. The managers were asked to indicate at what stage their respective factories were in in the adoption process. Fifty nine percent (59%) of the managers strongly disagreed, twenty nine (29%) disagreed and two percent (2%) did not know of presence of knowledge of CSPT in their factories. This was an acknowledgement of over ninety percent (90%) of the factories that had not started on the CSPT adoption process. This is a stage described as prior in the adoption process. They were not aware of the existence of the technology.

The other ten percent of the factory managers were aware of the CSPT technology, and actually three of them (5%) had made a decision to adopt the CSPT technology. However, they had not implemented the decision. They were still dealing with procurement logistics. Another three of the factories were aware of the technology, its benefits and possible challenges. They were still evaluating the option of adopting but had not made the decision. This results are illustrated in Table 1

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Table 1: Factories CSPT Adoption Stage

Adoption Stage	Frequency	Percent
Prior	60	90.9
Knowledge	3	4.5
Decision	3	4.5
Implementation	0	0
Confirmation	0	0
Total	66	100.0

The above distribution of the tea factories in accordance with their CSPT adoption status was tested for normalcy. This was by testing for skewness and kurtosis of the data. Skewness is a measure of data asymmetry with the normal distribution having a skewness value of zero (Hippel, 2013). A data distribution with skewness value two times or more of the skewness standard error is considered asymmetric, and therefore not normal. Skewness value for the CSPT adoption by tea factories status data was calculated at 2.809, with a standard error of 0.295. This skewness value is almost ten times its standard error and therefore implies that the distribution of data on CSPT adoption status of the tea factories is not normally distributed. Kurtosis is a reference of the extent to which observations cluster around a central point. For a normal distribution kurtosis is scored at zero. Any significant departure from this score reflects a distribution that is not normal. The data on factory CSPT adoption status was scored at 6.9. This finding supports the skewness measure results for a conclusion that the factory CSPT adoption status data is not normally distributed. These findings are illustrated in Table 2.

Table 2: Factory CSPT Adoption Status Skewness and Kurtosis

	N	Mean	Std. Deviation	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
CSPT Adoption	66	1.2727	.75540	2.809	.295	6.900	.582

The factory CSPT adoption status data distribution was also assessed using a Q-Q plot (quantile-quantile plot). This is a graphical tool used to test whether a data set is normally distributed. It is preferred because it see at a glance if normality assumption is plausible. A normal distribution will usually result in a straight line plot, and a curved plot indicates data that is not normally distributed. The Q-Q plot for the factory CSPT adoption status data is illustrated in Figure 2 below. The observed values plots are way off the normal distribution expected plot, again confirming the factory CSPT adoption status data is not normally distributed.

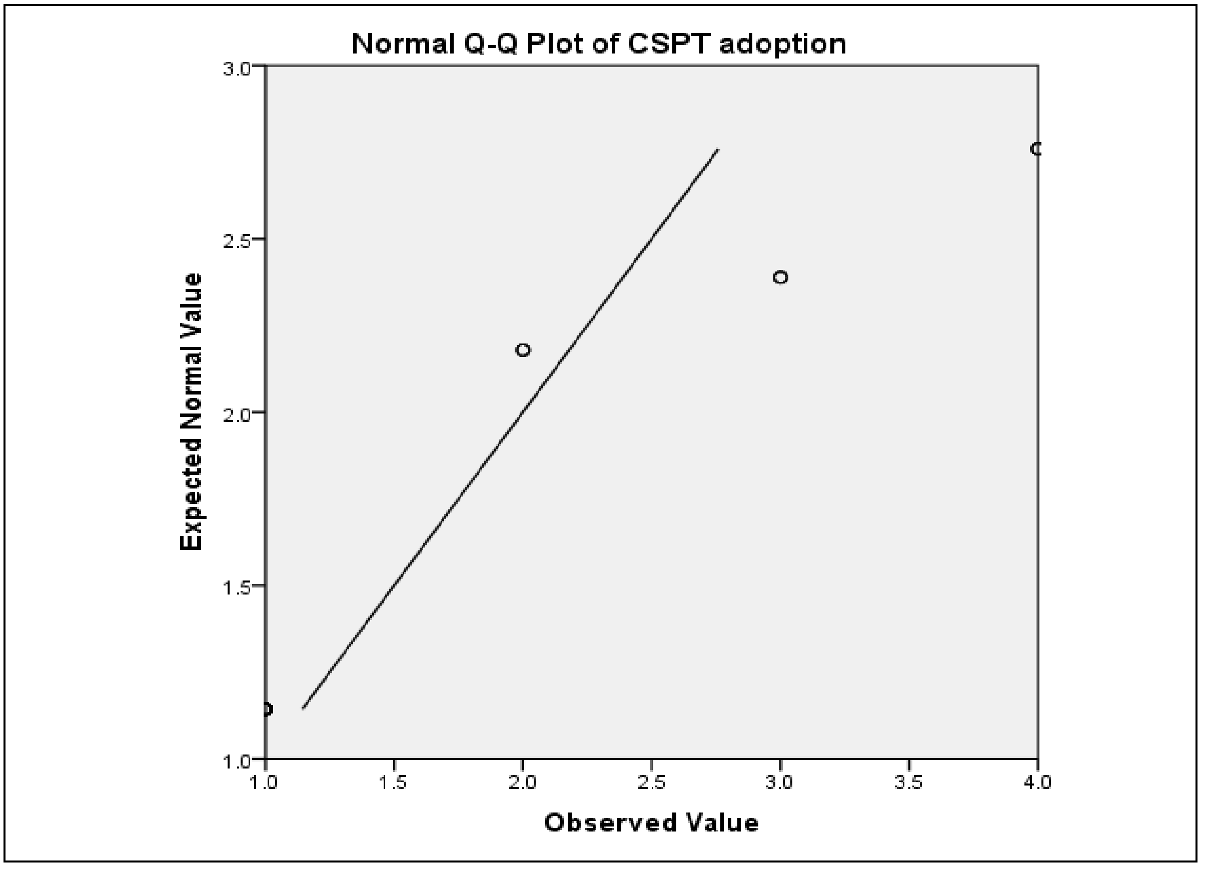

Figure 2 Factory CSPT Adoption Status Q-Q plot

Attributes and Likelihood of CSPT Adoption

The general objective of this study focused on the likelihood of CSPT attributes to influence the adoption of CSPT technology among tea factories managed by KTDA. These attributes were cost of CSPT, minimizing carbon emissions, minimizing health hazard, being a twenty four hour source, being within required heat range, being easy to install, and being triable.

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Descriptive Statistics of Product Attributes

Responses on of each of the product attributes on their likelihood to influence the adoption of CSPT are detailed in Table 3 below. The responses were on the extent to which the managers strongly disagreed (SD), disagreed (D), did not know (DK), agreed (A) or strongly agreed (SA) on an attributes likelihood to influence adoption of CSPT by their factories. All the six attributes scored a mean between 4 and 5 (out of 5), which is quite high. The most preferred attribute by the respondents, which would most likely influence adoption of CSPT, was 'being in the required energy range' of the factory. The tea factories require heat energy of a maximum 100^0C for drying or withering. This attribute attained a mean score of 4.62, with 62% factory managers strongly agreeing and 38% agreeing that it can enhance adoption of CSPT. This is a 100% agreement. It was followed by 'being a twenty four hour source' with a mean of 4.61. This is the advantage of CSPT being available day and night through sunlight during the day, and stored solar energy at night. This attribute had a 61% strongly agree and 39% agree ratings on its likelihood to influence the adoption CSPT. The third ranked attribute was 'being cost effective' with a mean score of 4.47. This is the potential of CSPT being cheaper than current sources of heat energy for the tea factories, namely wood fuel and fuel oil. This attribute attained a 43% strongly agree and 57% agree ratings from the managers.

Beyond these three attributes the other four attributes also scored high mean scores of over 4.2. 'Being easy to install' had a mean of 4.37, with 50% strongly agree and 50% agree ratings. The attribute 'minimize carbon emissions' scored 4.36, with 36% strongly agree and 64% agree ratings. Ability to 'minimize health hazards' had a mean score of 4.29 with strongly agree approval of 29% and 71% agreeing. The last one was 'being triable before purchase' with a mean score of 4.24 and 24% strongly agree and 76% agree ratings. The average of the mean scores is 4.44 (out of 5) with a standard deviation of 0.182. This is an indication that of all the attributes were considered important and likely to influence CSPT adoption by the respondents. The standard deviation implies that the distribution of responses cluster around 4.44 with lowest possible score of 4.258 and highest possible score of 4.622. As mentioned earlier CSPT is environmental friendly, poses no health hazards to workers, and its cost regime has been plummeting and is therefore very promising. It therefore seems CSPT has most of the attributes that respondents claimed would make them make an adoption decision.

Table 3: Descriptive Statistics of CSPT attributes

CSPT Attribute	Percentage					Mean	Std. Dev
	SD	D	DK	A	SA		
More cost effective	0	0	0	53	47	4.47	0.503
Minimizes carbon emissions	0	0	0	64	36	4.36	0.485
Minimizes health hazards to employees	0	0	0	71	29	4.29	0.456
Is a twenty four hour source of heat energy	0	0	0	39	61	4.61	0.492
Heat energy in the range requirement of the factory	0	0	0	38	62	4.62	0.489
Is easy to install	0	0	0	50	50	4.50	0.504
Triable before purchase	0	0	0	76	24	4.24	0.432
Average						**4.44**	**0.182**

Inferential Statistics of Product Attributes and CSPT Adoption

The general objective of this study was to assess the likelihood of cost effectiveness to influence the adoption of CSPT by the Kenyan tea factories run by KTDA. To enable measurement as to whether CSPT attributes can influence CSPT adoption among the tea factories, a hypothesis was derived that would be tested using the findings of the field study. The hypothesis was:

$H_0$8: There is no significant relationship between CSPT attributes and adoption of CSPT among the Kenyan tea factories run by KTDA.

To test the hypotheses for the influence of all the attributes on CSPT adoption, the product attributes data and CSPT adoption data were fitted in a Firth logistic regression model. The results of the regression are detailed in Table 4.

Table 4: Model CSPT adoption and CSPT attributes Statistics

Model: Firth Logistic regression (logitf) (Attributes.sav1.saved)

Prob> chi^2 = 0.0330

McFadden R^2=0.4135

	Constant B_0	Cost Effect	Minim Carbon	No Health Hazard	Twenty Hour hr.	Heat Range	Easy to Install	Triability
Estimate	-3.8947	1.6837	0.4788	1.2464	1.9800	1.0119	0.3358	0.6554
p-value	0.5212	0.0483	0.0375	0.04028	0.0333	0.03175	0.07359	0.04083
Odds ratio	0.0203	5.3854	1.6141	3.4778	7.2430	2.7508	0.7147	1.9260

The model attained R^2 of 0.4135 of the McFaddens' R^2 static of model fitness. This was slightly off the perfect fit of between 0.2 and 0.4, meaning the model slightly over-fits. This measures how well the model can be used to predict CSPT adoption from the attributes. In this case the model slightly exaggerate the Adoption. The model was statistically significant with a Chi^2 score of 0.0330. This implies that the model of the CSPT attributes and the covariates explains the likelihood of the adoption of CSPT better than a model with only the intercept at a confidence level of 95%. This conclusion leads to the rejection of the hypothesis to the general study objective which stated that 'There is no significant relationship between CSPT attributes and adoption of CSPT among the Kenyan tea factories run by KTDA'. By implication then, according to the findings of this study the seven CSPT attributes considered together have a likelihood of influencing adoption of CSPT by tea factories in Kenya.

Further, the significance of each of the attributes in the model were calculated at 0.05 level of significance. Six of the attributes had p-values of less than 0.05, meaning they were statistically significant. These were 'cost effective' at 0.0483, 'minimize carbon emission' 0.0375, 'no health hazard' at 0.040, 'twenty four source' at 0.0333, 'being within heat range' at 0.03175 and ' being triable' at 0.04083. All these six attributes were found to be significant at 95% confidence level. These results consequently led to the rejection the null hypotheses of the study regarding these attributes. The first hypothesis, $H_0 1$**,** which stated 'There is no significant relationship between cost effectiveness attribute of CSPT and adoption of CSPT among the Kenyan tea factories run by KTDA' is rejected, implying that cost effectiveness can influence the adoption of CSPT among the tea factories. The third hypothesis, $H_0 3$**,** which stated that 'There is no significant relationship between less health hazards attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya' was rejected, implying that less health hazards can influence the adoption of CSPT among the tea factories. The forth hypothesis, $H_0 4$**,** which stated that 'There is no significant relationship between twenty four hour availability attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya' was rejected, implying that twenty four hour availability can influence the adoption of CSPT among the tea factories. The fifth hypothesis,

H_05**,** which stated that 'There is no significant relationship between acceptable heat range attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya' was rejected, implying that acceptable heat range can influence the adoption of CSPT among the tea factories. The sixth hypothesis, H_06**,** which stated that 'There is no significant relationship between minimize carbon emissions attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya' was rejected, implying that minimize carbon emissions can influence the adoption of CSPT among the tea factories. The seventh hypothesis, H_07**,** which stated that 'There is no significant relationship between triability attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya' was rejected, implying that triability can influence the adoption of CSPT among the tea factories.

The last attribute 'being easy to install', had a p-value score of 0.07359, which exceeds the 0.5 threshold. It is therefore not statistically significant which means it cannot be expected to influence the adoption of CSPT at 95% confidence level. The second hypothesis, H_02**,** which stated that 'There is no significant relationship between being easy to install attribute of CSPT and adoption of CSPT by the KTDA run tea factories in Kenya', was accepted, implying that being easy to install cannot influence the adoption of CSPT among the tea factories. This particular attribute will therefore be excluded from the model. The model earlier expressed in equation (i) now crystalizes to equation (ii) below.

The other output of the analysis is parameter estimates (regression coefficients) of each independent variable in the model. These parameters shows extent to which a change in a predictor variable would influence the response variable when all the other predictor variables are in play. The attribute 'being a twenty four hour source' had the highest coefficient of 1.98 followed by 'being cost effective' with 1.68, and the third was 'minimizing health hazard' with 1.25. These three attributes can therefore be considered to be the ones likely to influence adoption of CSPT most. The other attributes would be less influential with 'being in the energy heat range' at 1.012, 'being triable' at 0.655, and 'minimize carbon emissions' at 0.488. The last one, 'easy to install' has a negative coefficient suggesting its contribution to adoption might be negative.

$$\textbf{Logist}\boldsymbol{f}\ \textbf{(CSPT Adoption)} = \mathbf{-3.8947 + 1.684Costef + 1.246Hhzd + 0.98Twty4h +}$$
$$\mathbf{1.012Hrange + 0.479MinCarb + 0.6554Triabl} \qquad \mathbf{(x)}$$

Odd ratios for each of the attributes were calculated. Odd ratio shows the extent to which a predictor variable can change the response variable when the predictor variable is changed by one unit, all the other factors remaining constant. The ratios, therefore, indicate the likely change in the dependent variable occasioned by variance of each independent variable considered alone. In this respect the highest odd ratio was that of the 'being twenty four hour source' attribute at 7.24. This means that if any contribution in making the CSPT a twenty four hour source is likely to cause a rise in adoption of CSPT by over seven times. The second attribute in this respect was 'being cost effective' at 5.385, while the third was 'no health hazard' at 3.478. These three are the attributes that are individually likely to spur higher adoption of CSPT among tea factories managed by KTDA. 'Being within heat range', 'being triable' and 'minimize carbon emissions' also are likely to have significant influence on CSPT adoption with their respective odd ratios of 2.75, 1.926, and 1.614. 'Being easy to install is likely to have the least influence with a ratio of 0.7147.

The above results show that CSPT attributes individually and severally are highly likely to influence adoption of CSPT among tea factories managed by KTDA. This assertion is based on the high mean scores (all over 4 out of 5) and significances of the covariates. This is in line with the emphasis by Rogers on the importance of product attributes in influencing adoption, claiming they account for 49% to 87% of adoption variance (Feng, 2012). Though specific product features were not cited in the empirical studies discussed earlier in this study, their importance was boldly underlined. In the two projects conducted in India on CSTs, product attributes were showcased in pilot demonstrations (on viability of CSTs), case studies and success stories (Ocampo & Marthel, 2012; Akker & Aggarwal, 2015; UNDP, 2015). Further reports were prepared on the salient features of CSTs.

Discussions

To attain the general objective of the study the factory managers were asked their opinion on the extent to which they agree or disagree with the likelihood of each of the seven CSPT attributes to influence adoption of CSPT by their factories. The general hypothesis was that there is no significant relationship between CSPT attributes and adoption of CSPT among the Kenyan tea factories run by KTDA. The study outcomes show there is a significant and positive relationship between CSPT attributes and CSPT adoption. Their relationship slightly over-fitted with McFadden R^2 of 0.4135 but were significantly related with a chi^2- p value score of 0.0330. Six specific attributes of CSPT (cost effectiveness, less health hazards, twenty four hour availability, acceptable heat range, minimize carbon emissions and triability) were found to have a positive relationship with adoption of CSPT. However ease of installation was found to be insignificant.

The above results show that CSPT attributes individually and severally are highly likely to influence adoption of CSPT among tea factories managed by KTDA. This assertion is based on the high mean scores (all over 4 out of 5) and significances of the covariates. This is in line with the emphasis by Rogers on the importance of product attributes in influencing adoption, claiming they account for 49% to 87% of adoption variance (Feng, 2012). Though specific product features were not cited in the empirical studies discussed earlier in this study, their importance was boldly underlined. In the two projects conducted in India on CSTs, product attributes were showcased in pilot demonstrations (on viability of CSTs), case studies and success stories

(Ocampo & Marthel, 2012; Akker& Aggarwal, 2015; UNDP, 2015). Further reports were prepared on the salient features of CSTs. All these initiatives are in agreement with the findings of this study.

Conclusion

The general study objective was 'to assess the effect of CSPT attributes on the adoption of CSPT by the Kenyan tea factories run by KTDA'. The CSPT attributes investigated were CSPT cost effectiveness, minimizing carbon emissions, minimizing health hazard, being a twenty four hour source, being within required heat range, being easy to install, and being triable. All the attributes were found to be significant in their likelihood to influence the adoption of CSPT except 'being easy to install'. CSPT attributes, therefore have a likelihood of influencing the adoption of CSPT by the tea factories managed by KTDA. This result led to the rejection of the null hypothesis 'There is no significant relationship between CSPT attributes and adoption of CSPT among the Kenyan tea factories run by KTDA'.

Recommendations.

From the findings and conclusions of this study CSPT attributes were found to have a likelihood to influence the adoption of CSPT. In the view of the researcher, to enhance likelihood of adoption of CSPT by the factories through influence of CSPT attributes, the attributes need to be made apparent to the factory management. This, like in the projects in India cited earlier, will be attained through awareness campaigns on the existence and attractive features of CSPT, exhibitions, demonstrations and electronic publications in web pages. Case studies on successful projects will also enhance the likelihood of the CSPT features influencing CSPT adoption. These would minimize uncertainty of the technology and enhance the chances of CSPT adoption.

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