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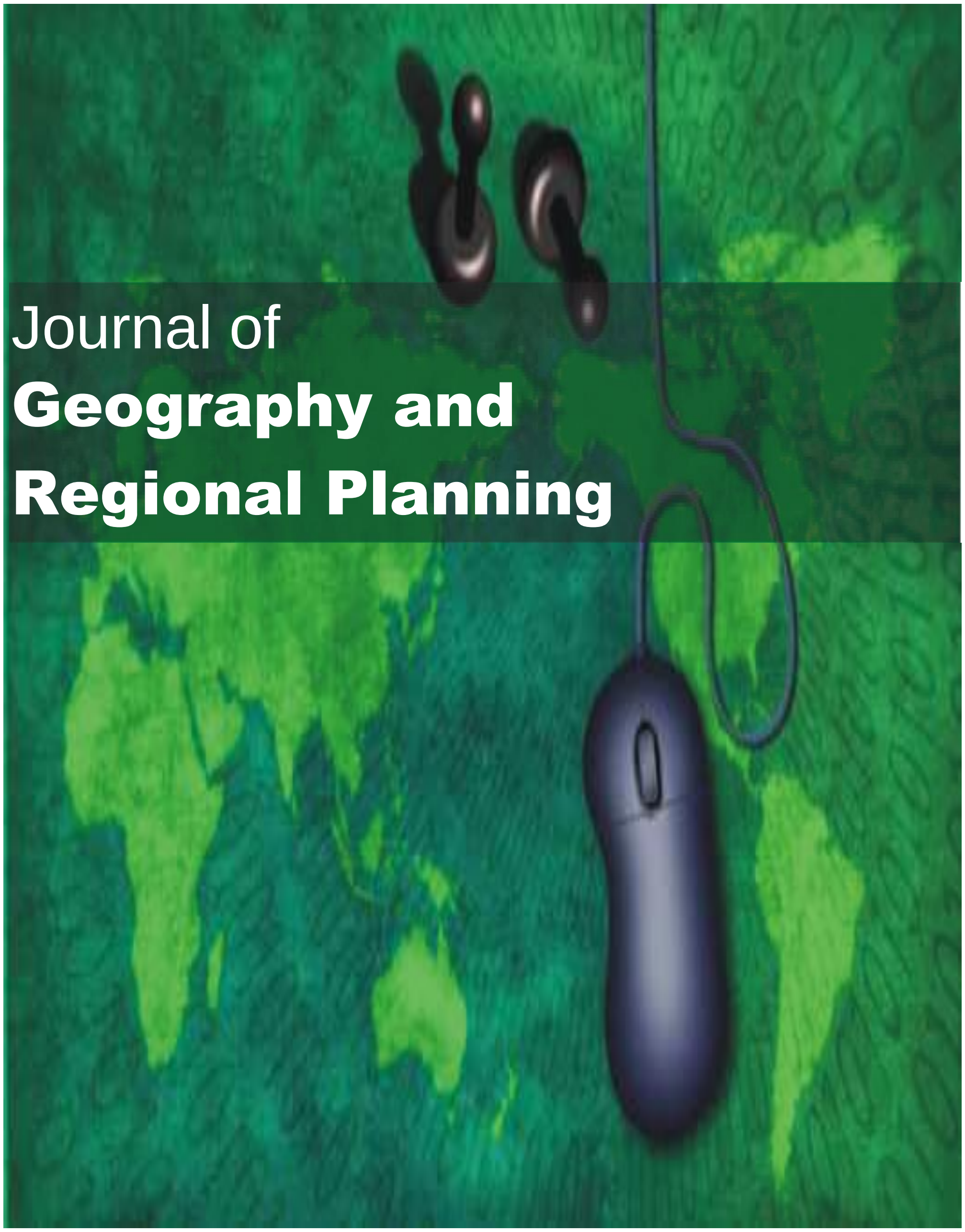

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Full Length Research Paper

Drivers to energy efficiency development in lighting and air-conditioning systems in manufacturing industries in Ghana for 2018

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The increase in electricity demand, coupled with drastic deficit in energy generation and depleting conventional energy resources continues to create complex challenges for the energy market in Ghana. But Energy Efficiency (EE) in lighting and air-conditioning has been considered as a green area for reducing energy consumption. The manufacturing sector has been considered as a key area for the implementation of energy efficiency practices. This paper presents a survey to assess the drivers to energy efficiency in lighting and air-conditioning systems from the perspective of two manufacturing industries. Questionnaires were distributed to 260 employees in two manufacturing industries in Ghana. Key informant interviews were carried with four respondents. The impact of employee gender, department of work and job position in mediating the drivers of EE was also assessed using correlation analysis. The results showed that the staff of manufacturing industries sees the availability of information on energy efficiency measures, staff awareness and knowledge and the availability of funds as leading driversto energy efficiency development. Also providing incentives in the form of awards to employees for energy efficiency participation was shown to be effective in the implementation of EE measures.The inferential statistics showed that employees' gender, department and job position predict the barriers to energy efficiency in the manufacturing industries. However, few of the drivers of energy efficiency are not dependent on gender, department of work and job position.

Key words: Energy efficiency, energy consumption, drivers.

INTRODUCTION

The increase in electricity demand, coupled with drastic deficits in energy generation and depleting conventional energy resources continue to create complex challenges for the energy market in Ghana. Electricity consumption is on a faster rate of rise than other energy vectors due to electrification of energy uses (International Energy Agency, 2017). Demand for electricity in Ghana which has since 2006 to 2016 increased by 52% is challenged by factors including persistent outages (Kemausuor et al., 2011; Gyamfi et al., 2015; Kumi, 2017). The persistent outages are the result of over dependence on the Akosombo Dam, high levels of distribution losses, non-payment of bills, over consumption of energy and a poor tariff structure (Energy efficiency (EE) explained as the

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more output per unit of input (Patterson, 1996), has emerged as one of the rewarding pathwaysto provide the quickest, cleanest and cheapest and innovativeway to reduce electricity demand (Gellings, 2009). Energy Efficiency (EE) procedures applied in industry include monetary activity such as value addition (Ang and Xu, 2013), and for petrochemical industries they include: decreasing fossil fuel and electricity demand by increasing heat integration within individual processes and across the total cluster site; replacing fossil feedstock with renewable and bio-refinery integration with the existing cluster; and increasing external utilization of excess process heat wherever possible (Hackl and Harvey, 2013). Specifically for lighting and air-conditioning (AC) in industries, EE measures have involved the use of efficient lighting devices, energy labelling of new refrigerators, SWH instead of diesel, gas or electric boilers, high efficient motors, and properly adjusting HV AC and steam boilers to save an average of 15% on energy consumption (Bose, 1992; Mahmoud and Ibrik, 2002; Ibrik and Mahmoud, 2005). Many arguments which cited the need for energy efficiency to provide a win-win opportunity for energy demand-supply matrix do not meet modern standards of credibility and empirical evidence (Allcott and Greenstone, 2012). In Ghana, the energy efficiency concept has to date received little attention (Gyamfi et al., 2018). Programs toward energy efficiency have focused predominantly on the residential and commercial sectors. However, the contribution of industries to the heightening of electricity demand cannot be under-estimated (Owusu, 2010; Energy Commission, 2017). Therefore, exploring an empirical study that examines opportunities for energy efficiency is critical (Allcott and Greenstone, 2012).

Electricity usage in industries, lighting and air-conditioners continue to be the major consuming devices of electricity in developing countries like Ghana. It is reported that electricity consumption by cooling using air conditioners in manufacturing industries would offer a potential of 8% savings in Ghana through the proper enforcement of energy efficiency standards (Koizumi, 2007; Gyamfi et al., 2017; Gyamfi et al., 2018). It is therefore a wakeup call to promote energy efficiency measures for optimal electricity usage in lighting and air-conditioners.

Efforts to promoteenergy efficiency in lighting and air condition in the industrial sector over the yearshave proved futile because of the lack of understanding on the drivers towards energy efficiency. Many different theoretical approaches to drivers of EE have been advanced in the relevant literature (De Groot et al., 2002; DeCanio, 1998; Trianni et al., 2013). However, few studies exist for drivers of energy efficiency (Cagno et al., 2013), the studies focus on which drivers should be highlighted but not for the decision-making process (Cagno et al., 2014). Some studies have shown that key knowledge of the economic, behavioural, organizational, informational and technological-related drivers can help generate initiatives towards energy efficiency as well as harness the full potential of energy efficiency in the manufacturing industries (Spallina and Marchesani, 2012; Apeaning and Thollander, 2013). Kambule (2014) have revealed that gaps between adoption and perception of Energy Efficiency (EE) can be the result of several drivers including shortfalls in finance, human skills, time, training and information. These arguments therefore call for further investigation into possible factors that can mediate drivers to EE.

A number of studies have found gender to mediate pro-environmental attitudes (Kollmus and Agyeman, 2002; Tindall et al., 2003; Gifford and Nilsson, 2014). Kollmuss and Agyeman (2002) in a paper "minding the gap: why do people act...barriers to pro-environmental behaviour" argue that although women have less extensive knowledge than men,women are found to be more emotionally engaged and as a result tend to show more concern in relation to environmental destruction, they believe less in technological solutions, and are more willing to change behaviour. But Gifford and Nilsson (2014) are of the view that gender differences that influence pro-environmental concerns and behaviours fails to work outside the home. In Ghana where gender differences occur for people working in the industrial sector (Amu, 2005; Heintz, 2005; Peprah, 2011), it is important to explore measures to address gender impact differences associated withdrivers ofEE.

Other factors having the potential to mediate drivers to EE are the type or department of work. Schleich (2009) in 'an exploration of drivers to energy efficiency' identifies a heterogeneous picture of sector-specific differences in the relevance of the individual drivers of EE. The heterogeneity in the EE differences is independent of an organization's EE performance. Organization, therefore, under-estimates the internal priority setting as a barrier to EE when dealing with planned projects (Schleich, 2009).Linked to an employee's department of work,as predictors of the drivers to EE, is that of the position held by the employee in the industrial sector.

The work schedule of an employee in terms of occupancy behaviour, can significantly impact on energy in terms of energy end use levels such as lighting, space cooling and heating (Hong and Lin, 2013). The impact of who occupies a building may be translated as 50% less energy for austerity lifestyle, while the wasteful work style consumes up to 90% more energy. Other studies by Brummelhuis et al. (2012) in 'do new ways of working foster work engagement?' identified that flexible work designs, including those of management and higher level employees allow employees to schedule work to suit the best situation, thereby saving time and energy. It is essential to explore, whether the schedule of employees in the industrial sector in Ghana can predict drivers of EE for lighting and AC

In spite of the many works that have assessed the drivers to EE in manufacturing industries, it is interesting to point out that much of the literature has failed to address the levels of dependence of energy efficiency drivers in the manufacturing sub sector which is critical for understanding the dynamics ofdrivers to energy efficiency. Moreover, there are limited works that address the drivers to EE implementation in lighting and air conditioning in Africa and for that matter Ghana.The paper also explores gaps in the EE literature including whether gender, type/department of work and position in employment can predict the drivers of energy efficiency in lighting and air-conditioning systems in manufacturing industries in Ghana.

This work seeks to study the key drivers that influence the implementation and development of energy efficiency practices that drive EE performance in the manufacturing sub sector of Ghana.

MATERIAL AND METHODS

A descriptive design that explored the perceptions of people on key drivers of EE was applied to provide an in-depth investigation into lighting and AC for the manufacturing sub-sector of Ghana. A mix of quantitative and qualitative designs was considered for the study. The quantitative approach was used to gather quantitative data from respondents whilst the qualitative data provided clarifications to the statistical values obtained from the quantitative data.

A population of 774 representing 636 and 138 from a food manufacturing company and cement manufacturing company respectively was used for the study. These companies were selected due to their location, diversity of energy usage, and high production levels that demanded a higher consumption of energy as well as the urgency to ensure energy efficiency. A sample size of 260 was sampled for the study (Twumasi et al., 2017). The distribution of the sample is shown in Table 1.

A number of sampling frames were applied to the study. These included a purposive frame to pre-select the two companies, a cluster of departmentalization for each company, that is, Engineering and non-Engineering sections of the company and a random sampling approach to select the required number of respondents for each company. Only Straight day workers were asked to complete the questionnaire in order to ease the collection of completed questionnaires whilst heads of the engineering and non-engineering sections of the two industries were purposively selected for the interviews. The survey questions were carefully selected from a review of available literature and pretested for clarity and reliability and into simple and understandable terms. Preliminary studies were performed on five employees to ensureclarity of the questions. The questionnaires highlighted the drivers to energy efficiency.

Questions were categorized into three sections; background description, assessment of motivation measures for employee engagement in energy efficiency and assessment of the drivers to energy efficiency in lighting and air-conditioning systems in manufacturing industries. Background description explores gender, department of work, and position of employees to assess whether those variables can predict the drivers and motivational variables of EE in the two selected industries. Drivers were explored under the same variables because they provided the underlying information on assessment of EE in lighting and air-conditioning systems. Variables considered under drivers therefore included availability of information on EE measures, funds, staff awareness and knowledge, and recognition of the environmental benefits of EE. Motivational measures available and applicable in these two industries, that is, the two main awards for applying EE were assessed. These were quarterly awards for adopting innovative ideas on EE and quarterly departmental award system for the most EE department.

The questionnaires were analyzed using the Statistical Package of Social Science (SPSS) version 21. The Respondents indicated their level of agreement with the statements by basing on a 5-point Likert Scale. Each level on the scale was assigned a code ranging from strongly agree, agree, neither/uncertain, disagree to strongly disagree. The findings were then presented in charts, graphs, and tables using descriptive statistics, frequency analysis tools and the cross-tabulated analysis in order to evaluate the relationship between variables of the data. The chi-square analysis, a non-parametric test, was used to establish the relationship between the variables. This inferential test was then used to understand the relationship between employee's gender, department of work and job position and the various drivers to energy efficiency.

An interview guide was used to conduct interviews with key informants from the two industries. The face-to-face interviews used covered respondents representing the engineering and non-engineering sections of the two industries. Questions used for the interview included: what are your thoughts on drivers to EE in lighting and air-conditioning systems in your industry? And what are the motivational tools applicable to EE in lighting and air-conditioning systems in your industry? In all, four (4) interviews were conducted. The transcripts were grouped into themes that directly reflected the objectives of the study. These themes were used to provide clarifications for descriptive statistics obtained from the quantitative data.

RESULTS

Demographics of respondents

The demographics of respondents are shown in Table 2. The scores indicate a higher (76.7%) representation for males as against female respondents. Department of respondents were categorized under 43.2 % (102) for engineering and 56.8% (134) for non-engineering departments. The majority (52.2%) of respondents are technicians, 39.8% are supervisors and 7.6% are managers.

It is important to note that the higher representation for supervisors and technicians is good for a good assessment of the study variables since these respondents are more knowledgeable about the issues of drivers to energy efficiency and are directly involved in the use, monitoring and maintenance of the equipment in the manufacturing industries. The gender card plays well in favour of males because it is generally assumed that the strenuous nature of work and working conditions in the industrial sector make it more favourable for males than females.

Assessment of the drivers to energy efficiency in manufacturing industries

Respondents were assessed on the drivers to energy efficiency in the manufacturing industries as indicated under Table 3.

Table 1. Questionnaire distribution.

Company Name	Staff population	Questionnaire distribution	Number of questionnaires retrieved	response rate
Food processing industry	636	160	136	85%
Cement industry	138	100	83	83%
Total	774	260	219	-

Source: Field work (2018).

Table 2. Demographics of respondents.

Variable		Frequency	Percentage (%)
Gender	Male	181	76.7
	Female	55	23.3
Department	Engineering	102	43.2
	Non-Engineering	134	56.8
Position	Manager	18	7.6
	Supervisor	94	39.8
	Technician	124	52.5

The study results show that over 60% of respondents agree that lack of information on EE measures is a key driver of EE as against 20.8% that disagreed. On the issue of fund availability, there was a near split on whether it was a driver or not. Generally, scores for agreement were higher than those who disagree for all aspects of drivers to EE in lighting and air-conditioning in the two industries studied. Mean scores for drivers to energy efficiency showed that respondents agree that the main barrier and driver of EE is lack of funds (mean= 2.99), followed by lack of technical skills (mean=2.86). Key informants indicated that EE policies are good and their companies have good and documented policies for achieving EE; however, the requisite funds to support such innovative ideas are difficult to access in their establishments. Other arguments cited EE policy implementation as creating additional cost implications usually beyond the financial capabilities of their organizations. The least scoring driver to energy efficiency in the manufacturing sector is lack of information in energy efficiency measures (mean= 2.4). Informants agreed that information on EE measures do exist but the cost implication of carrying out such measures prevents the industries from meeting their EE obligations.

Assessment of motivation measures for employee engagement in energy efficiency

The results show that the majority (82.2%) of respondents agree that quarterly awards are given to motivate employees who apply innovative ideas on EE (Table 4). This development is also evident for departments that excel as the most energy efficient department. It came out that issuing quarterly departmental awards for most energy efficient departments (mean=1.89) was the more popular option than that of providing quarterly awards for innovative ideas on energy efficiency (mean=1.85). This shows that respondents are more interested in the direct benefit of ensuring energy efficiency in the departments within the organization.

Correlation analysis

Drivers to energy efficiency measures by gender of respondents

Table 5 explores the relationship between the drivers to energy efficiency and gender of employees. Generally, males performed better where gender was a deciding factor in mediating drivers to EE in lighting air-conditioning industries in Ghana, except for recognition of environmental benefits of EE where women performed better than males (Table 5). This development can be attributed to the fact that the number of females working in the selected industries and the industrial section in general are skewed with respect tomales. This scenario is essentially worse when it comes to the engineering and non-engineering sectors of industries where males also males also dominate for engineering.

Scores on correlation showed that most of the drivers

Table 3. Drivers to energy efficiency in lighting and air-conditioning for selected manufacturing industries.

Variable	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Mean($\bar{x}$)	Std. deviation (s)
Lack of information on energy efficiency measures	25	35.6	18.6	16.1	4.7	2.40	1.161
Lack of funds	14.8	26.3	16.9	28.8	13.1	2.99	1.295
Lack of technical skills	18.2	23.7	19.5	30.9	7.6	2.86	1.252
Lack of staff awareness and knowledge	25.0	26.3	25.4	19.1	4.2	2.51	1.180
Lack of recognition to environmental benefits	18.6	35.2	25.8	15.3	5.1	2.53	1.112

Table 4. Motivation measures for employee engagement in energy efficiency in lighting and air-conditioning in selected industries.

Variable	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Mean($\bar{x}$)	Std. deviation(s)
Quarterly awards to innovative ideas on energy efficiency	43.6	38.6	8.5	8.1	1.3	1.85	0.969
Quarterly departmental award system for most energy efficient department	42.8	35.6	12.3	8.1	1.3	1.89	0.990

Table 5. Relationship between drivers to energy efficiency in lighting and air-conditioning in selected Industries by gender.

Activity	Gender				Estimation of Importance of driver X by gender	Pearson chi-square	p-value
	Male		Female				
	Responding better	Responding worst	Responding better	Responding worst			
Information on energy efficiency measures	63.6%	22.1%	50.9%	16.3%	Males performed better	10.479	0.033
Availability of funds	44.2%	39.8%	30.9%	49.1%	Males performed better	4.505	0.342
Availability of technical skills	48.1%	38.6%	21.8%	38.1%	Males performed better	24.938	0.000
staff awareness and knowledge	53.6	24.3%	43.6%	20%	Males performed better	5.227	0.265
Recognition to environmental benefits	52.4%	24.3%	58.2%	7.3%	Females performed better	11.622	0.020

dependent on the employee's gender, only drivers such as the availability of funds and staff awareness and knowledge were not related to the employee's gender. Key informants argued that the majority of the non-engineering staff are women who spend most of the working hours in the office and therefore women become the major beneficiaries of the use of lighting and air-conditioning in the industrial sector. It therefore speaks to the fact that any major decision to improve EE in the industrial sector will be successful if gender becomes a conduit.

Comparison of the drivers to energy efficiency measures by employees' department

Table 6 shows the relationship between drivers to energy efficiency and employee's department. The scores show that non-engineering performed better than engineering for all aspects of the drivers. This result also supports earlier submissions indicating that the department of work is gender sensitive; and is skewed towards more females in non-engineering sections. These respondents in the non-engineering departments represent a larger number of people who conduct their work in offices where lighting and air-conditioning are most evident. The department of the employee was revealed to be highly dependent on all variables under drivers and challenges to energy efficiency in lighting and air-conditioning except for recognition of

Table 6. Relationship between drivers to energy efficiency and employees department.

Activity	Department of work				Estimation of Importance of driver X by department	Pearson chi-square	P-value
	Engineering		Non-engineering				
	Responding better	Responding worst	Responding better	Responding worst			
Information on energy efficiency measures	56.9	27.4	63.4	15.7	Non-engineering performed better	0.006	0.006
Availability of funds	29.4	48.1	50	37.4	Non-engineering performed better	0.002	0.002
Availability of technical skills	36.3	53.9	46.3	26.8	Non-engineering performed better	0.000	0.000
Staff awareness and knowledge	45.1	29.4	56.0	18.7	Non-engineering performed better	0.039	0.039
Recognition to environmental benefits	52.0	24.5	55.2	27.1	Non-engineering performed better	0.091	0.091

Table 7. Relationship between drivers to energy efficiency and employees position.

Activity	Position						Estimation of importance of driver X by position	Pearson chi-square	P-value
	Manager		Supervisor		Technician				
	Responding better	Respondin g worst	Responding better	Responding worst	Responding better	Respondin g worst			
Information on energy efficiency measures	77.8	0.0	59.6	4.3	58.9	5.6	Manager performed better	5.091	0.748
Availability of funds	66.7	5.6	45.7	6.4	33.9	19.4	Manager performed better	19.673	0.012
Availability of technical skills	77.8	0.0	42.6	4.3	36.2	11.3	Manager performed better	17.622	0.024
Staff awareness and knowledge	83.3	0.0	53.2	5.3	45.2	4.0	Manager performed better	12.836	0.118
Recognition to environmental benefits	83.3	0.0	63.8	4.3	41.9	6.5	Manager performed better	19.619	0.012

environmental benefits which was not significantly related. Department of work does not predict recognition to environmental benefits because this variable is strongly represented by people in the non-engineering sections who are mainly females.

Relationship between drivers to energy efficiency and job position of employees

Table 7 shows the relationship between drivers to energy efficiency and employees 'job positions. The score for whether position can predict drivers to lighting and air-conditioning for the selected industries showed that managers performed better for all aspects of drivers to EE (Table 7). Scores for supervisors were also better than the technician for all aspects of drivers of EE for lighting and air-conditioning. The worst performing predictor variable under position was technician. Key informant interviews suggested that the trend in the scores is a reality since managers are policy makers, implementers and evaluators and are therefore highly rated in ensuring that the integrity of EE policies are adhered to in the establishment.

The analysis showed mixed results for whether position can predict drivers to energy efficiency for lighting and air-conditioning for the selected industries. Position of employees predicted all aspects of drivers of EE except for availability of information in EE measures and staff awareness and knowledge on EE.

DISCUSSIONS

Issues of Energy Efficiency in lighting and air-conditioning (AC) have become an area of increased interest for many industries due to the potential contribution it can have on efforts to meet the energy demands of the sector. This research examined drivers and drivers to EE in lighting and AC for selected industries, as well as exploring factors that can mediate these drivers. . Drivers of energy efficiency (EE) in lighting and AC in the manufacturing industry are rated from highest for availability of funds, then availability of technical skills, recognition to environmental benefits, awareness and knowledge on EE measures to the lowest, information on energy efficiency measures.The issue of non-availability of funds is highly rated due to its centrality in contributing to all the other drivers to support EE Although policydocuments and guidelines for applying EE are available, the non-availability of requisite funds prevents its implementation in many cases.The results support the available literature (Spallina and Marchesani, 2012; Apeaning and Thollander, 2013; Kambule, 2014; Ang and Xu, 2013) suggesting the centrality of funds availability as the main variable driving EE efforts in lighting and AC for manufacturing industries. Not-withstanding, this literature also emphasizes the important roles played by access to time, training, and relevant information in the drive to EE in the industrial sector.

Innovative measures applied by the manufacturing industries to encourage EE is mainly the institution of quarterly awards for employees that apply innovative ideas on EE followed by the application of quarterly departmental award systems to motivate workers towards EE. Provision of tangible motivational packages to staff for implementing EE measures, have the potential to yield more results. The approach to motivating staff that apply EE speaks to relevant literature in the sense that although it is generally agreed that EE provides a win-win opportunity for energy demand-supply matrix (Allcott and Greenstone, 2012), EE has received less attention in Ghana (Gyamfi et al., 2018) possibly because the motivation for its acceptance and application as applicable in this study has been low.

This study confirmed that gender plays key roles in mediating drivers of EE for availability of information on EE measures, availability of technical skills and recognition to the environmental benefits of EE but not for availability of funds and staff awareness and knowledge. Males were significantly better than females in predicting the drivers of EE in lighting and AC for the manufacturing industries except under recognition to environmental benefits where females performed better. Although women form the larger representation of the non-engineering staff who incidentally are mostly office staff that also spend hours of the day using lights and AC, it is significant to note that females performed worst in mediating many of the drivers to EE. The study results positively relate to Kollmuss and Agyeman (2002)'s paper of 'minding the gap: why do people act...drivers to ‘pro-environmental behaviour' who argued that women have better concern than men for environmental destruction, as well as being more willing to change behaviour including towards EE. Comparing the study results to Peprah (2011) shows a differing outcome since Peprah argued that gender and for this case women's mediated actions of EE are limited to the home rather than to the industrial settings.

The departments as well as job schedule of employees were identified to provide different results for the drivers to EE. Generally, the department of work was a significant factor mediating all aspects of drivers of EE in lighting and AC in manufacturing industries except for recognition of environmental benefits of EE. Meanwhile staff in the non-engineering sections of manufacturing industries perform better that those of their colleagues in the engineering section. The test for EE application will therefore provide some variability to the type of schedule an employee is assigned to in the industrial section. This is supported by the fact that the larger number of staff in the non-engineering section who incidentally are mostly females will predict EE policies and application since they are also in the offices where lighting and ACs are mostly used. To achieve success in EE policy implementation in the manufacturing industries, particular attention should be paid to the department of work of employees since the department of work can mediate drivers of EE in lighting and AC. The study further gives a boost to Schleich (2009) who explored barriers to EE and identified that a heterogeneous picture of sector-specific differences in the relevance of drivers to EE was evident, especially where the type of work performed in the industrial sector is to be considered as variable to explore the implementation of EE.

The roles assigned employees have the strength to mediate EE for lack of funds, technical skills and recognition to environmental benefits for the industrial sector. Issues of lack of information on EE measures, and staff awareness are on the other hand not affected by the positions of employees when their EE consciousness is assessed. In the study, managers performed better than supervisors and then technicians for all aspects of the drivers of EE in lighting and AC in manufacturing industries. The trend is a reflection of the critical roles such as policy formulation, implementation and monitoring mainly executed by managers rather than supervisors and technicians in the manufacturing industries. The results corroborates the findings of Hong and Lin (2013) that explored employee occupancy behaviour and found that the role of employees occupying building in industries can mediate energy use levels for lighting, space cooling and heating. The result is significantly related to Brummelhuis et al. (2012) who also identified that work schedule relating to managerial or supervisory roles can allow for flexible work designs to suit situations that positively impact on EE.

Conclusions

The research explored knowledge on the drivers to energy efficiency development in lighting and air-conditioning systems in manufacturing industries through the lens of two manufacturing industries in Ghana. The main driver of EE in lighting and AC for manufacturing industries is availability of funds to support EE policies. Other factors also driving EE range from availability of technical skills, recognition to environmental benefits, awareness and knowledge on EE measures and information on energy efficiency measures availability of information on energy efficiency measures, staff awareness and knowledge on EE measures and availability of funds as leading drivers to energy efficiency development. Policy implementers of EE should do what is necessary by providing the needed resources to support EE in lighting and AC in the manufacturing sectors since funds availability will go a long way in helping to assemble the other relevant drivers of EE. Innovative measures such as the award schemes should be channeled into EE activities since tangible motivational tools such as instituting awards for applying innovative ideas on EE as well as applying departmental awards for EE can go a long way to make efforts at promoting EE activities in lighting and AC for manufacturing industries a success.

Also, the inferential statistics showed that employees' gender, department and job position affect the barriers to energy efficiency in the manufacturing industries; however few of the drivers on energy efficiency were not dependent on gender, department of work and job position. Males are better predictors of drivers of EE than females except for recognition to environmental benefits. It is also important to note that EE policies in lighting and AC should mostly target females who are known to form a larger representation of non-engineering staff who incidentally are also located in the offices and extensively make use of lights and AC. EE policies should also concentrate on supervisors and technicians rather than managers since supervisors and technicians are weaker predictors of drivers of EE in lighting and AC for manufacturing industries.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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Population move on Rajasthan: Regional analysis

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The physiography of Rajasthan is not suitable for agricultural activity. Most parts of Rajasthan are sandy regions and Aravalli Mountain, which is a barrier for agriculture. Eastern part of Rajasthan is covered with plain soil but this region is also not suitable for agriculture. This is the reason why Rajasthan experienced a large proportion of out-migration from its different physiographic regions. The present research aims to investigate in details, the identification of out migration regions and regional flow of male migration with a geographical perspective. Analysis of inter-regional out-migration flow in Rajasthan was based on secondary data. The migration rates has been calculated for out-migration, in-migration, and net migration, as well as specific population subgroups using Clark method. The Eastern sandy arid region and Eastern plain region have experienced higher rate of inter-regional out-migration.

Key words: Male migration, source region, Rajasthan, physiographic region.

INTRODUCTION

Most parts of Rajasthan are covered with western sandy region (The Thor Desert) and Aravalli Mountain, which is a big barrier for agricultural activities. The Eastern part of Rajasthan is covered with plain sandy soil but this region is also not suitable for agriculture. This is the reason why this state experienced a large proportion of out-migration in different physiographic regions in Rajasthan.

Some scholars also studied the nature and trend of out-migration from Rajasthan. Some parts of Rajasthan which is located in central India have a long history of human migration (Hutton, 1986). Rural people of Rajasthan migrated to Maharashtra especially Mumbai (Carroll, 2010). The temporary migration is found higher than national average in Rajasthan (Saha and Kumar, 2008). Rajasthan and Gujarat have also experienced very high rate of out-migration, not only non-tribal areas but also tribal areas in Madhya Pradesh (MP), (Mosse et al., 2002).

Out-migration is a strategy that received landless agricultural labours and poor rural people (Keshri and Bhagat, 2012; Haberfeld et al., 1991). Good condition of transport, communication system and high employment opportunity are the basic factors for rural urban out-migration in any area (Battacharya, 1998; Gupta, 1993; Andrienko and Guriev, 2004).

The following objectives have been undertaken for this study that is to identify inter-regional source of out-migration in Rajasthan, and to analyse regional flow of male migration in different physiographic regions.

METHODOLOGY

Inter-regional out-migration flow in Rajasthan is based on secondary data. Secondary data were collected from migration table (D series,

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2001). The census of India provided enough data to analyse inter-regional migration flow and pattern of out-migration in Rajasthan.

The study was essentially based on 2001 migration data. Unfortunately, migration data for the 2011 census was yet to be released for Rajasthan. Migration rates can be calculated for out-migration, in-migration and net migration, as well as specific subgroups of population by Clark (1986) method:

$$Ir = \frac{I}{P}.K\ , \quad Or = \frac{O}{P}.K\ , \quad Nr = \frac{I-O}{P}.K$$

Where,

$Ir = In-migration\ rate,\ Nr = net-migration\ rate,\ Or = out-migrantsrate$

$O = number\ of\ out-migrants, I = number\ of\ in-migrants, P = Population,$
$K = constant\ (usually\ 1000\ or\ 100)$

Inter-regional out-migration analysis has been done by classifying all the districts of the state into physiographic region. In physiographic point of view, the state is divided into five broad regions that is, sandy arid plain, semi-arid plain/Bangur Region, Aravalli Range and Hilly Region, eastern plain and Hadoti Plateau regions for showing the out migration patterns. The districts have been taken as the basic unit of the study. As at 2001, there were 32 districts in Rajasthan.

Simple method was used for the analysis of net-migration or gain and loss migration. The sum of in-migrants and out-migrants represents the gross migrants; whereas net migration is calculated from in-migrants–out-migrants to total population (Census Atlas, 1971).

The study focus on the two streams of migration, total migration, and male out-migration. All the migrants will also be classified on the basis of distance: short (intra-district), medium (inter-district), and long (inter-state).

Inter-regional male outmigration will be analysed, using mean and standard deviation method. The inter-regional variation in out-migration at the district level used different statistical techniques like average mean of out-migration, standard deviation and co-efficient of variation.

RESULT AND DISCUSSION

Rajasthan is the largest state in India and is located at the western part of the country. It lies between 23°3’ N to 30°12’N and 69°30’E to 78°18’E. Rajasthan is bounded by Pakistan in the west and north-west, Punjab in the north, Haryana in the north-east, Uttar Pradesh in the east, Madhya Pradesh in the south-east, and Gujarat in the south-west India.

Due to the position of Araballi Hill in the middle portion of the state, Rajasthan is divided mainly into two parts, Eastern Rajasthan and Western Rajasthan. In physiographic point of view, there are five major regions (Joshi, 2008; Depan, 2011; Kumar, 2014) which are:

1. Western Sandy Arid Region (6 districts)
2. Semi-Arid Region (6 districts)
3. Araballi Range and Hilly Region (7 districts)
4. Eastern Plain (11 districts) and
5. Hadoti Plateau Region (3 districts).

Physiographic region does not follow any administrative boundary but for the purpose of analysis districts are classified under different regions (Table 1).

Inter-regional variation of out-migration

The entire study has been analysed on the basis of physiographic region. For the purpose of this study, a broad physiographic region again has been divided into sub-regions and region wise division has been done at district level.

Physiographic region does not follow any administrative boundary but for the purpose of analysis districts are classified under different regions. In recent decades, Rajasthan has faced a great proportion of out-migration from different regions. Inter-regional or inter-district outmigration rate is defined as the proportion of total out-migrants from the given region or district to total population of that region or district during the specific period of time (Nangia and Kumar, 2007).

The range of out-migration has been classified by using mean and standard deviation method. The rate of total outmigration varies significantly across the districts within and across physiographic regions (Table 2).

Figure 1 delineates the inter-regional distribution of total out-migration in Rajasthan. From the figure, it is clear that this state observed diverse nature of out-migration. Very high rate (above 8.91 %) of out-migration was observed in six districts among the thirty two districts in Rajasthan. Churu from Western Sandy Region; Sikar from Semi-arid Plain; Ajmer from Aravalli Range; Hilly, Dausa, Tonk and Sawai Madhopur districts from Eastern Plain regions experienced very high rate of out-migration. High rate (6.55 to 8.91%) of out-migration is found in northern part of Western Sandy Region, covering almost the entire region in Semi-arid Plain and parts of Hadoti Plateau and Eastern Plain regions.

From the aforementioned analysis it is clear that more than half of the districts that is, 18 in Rajasthan has observed high and very high rate of inter-regional or inter-district out-migration due to absence of job opportunity, agricultural suitability, accessibility, social and economic underdevelopment, etc (Figure 1).

The districts including the category of moderate rate (4.19 to 6.55%) of out-migration are mainly found in south-western part of Western Sandy Region, northern and southern part of Aravalli Range and Hilly, and southern part of Eastern Plain regions. From Table 2 it is clear that only four districts out of thirty two districts experienced low rate of inter-district out-migration in Rajasthan. Form this point of view, it can be imagined

Table 1. Classification of physiographical regions of Rajasthan.

Regions	Respective districts
Western sandy arid region	Jaisalmer, Barmer, Ganganagar, Hanumangarh, Bikaner, Churu
Eastern semi-arid plain	Jhunjhunun, Nagaur, Jodhpur, Jalor, Pali, Sikar
Aravalli range and hilly	Jaipur, Sirohi, Ajmer, Rajsamand, Udaipur, Dungarpur, Alwar
Eastern plain	Bharatpur, Dhaulpur, Karauli, Sawai Madhopur, Dausa, Tonk, Bhilwara, Budi, Chittorgarh, Banswara
Hadoti plateau	Kota, Jhalawar, Baran, Bundi

Source: Joshi (2008), Depan (2011), Kumar (2014).

Table 2. Inter-regional out-migration pattern in Rajasthan, 2001.

Category	Range	Districts	No	Physiographic regions
Very high	Above 8.91	Churu Sikar Ajmer Dausa, Tonk, Sawai Madhopur	6	Western Sandy Region Semi-arid Plain Aravalli Range and Hilly Eastern Plain
High	6.55-8.91	Ganganagar, Hanumangarh, Bikaner Jhunjhunun, Nagaur, Jodhpur, Pali Rajaamand Karauli, Bundi Baran, Kota	12	Western Sandy Region Semi-arid Plain Aravalli Range and Hilly Eastern Plain Hadoti Plateau
Moderate	4.19-6.55	Jaisalmer, Barmer Sirohi, Udaipur, Jaipur, Alwar Bharatpur, Bhilwara, Chittaurgarh Chalawar	10	Western Sandy Region Aravalli Range and Hilly Eastern Plain Hadoti Plateau
Low	Below 4.19	Jalor Dungarpur Dhaulpur, Banswara	4	Semi-arid Plain Aravalli Range and Hilly Eastern Plain

Source: Census of India, Rajasthan, migration table: D-11: Persons born and enumerated in districts of the state.

that most of the districts in Rajasthan are faced with high risk of out-migration.

From the physiographic point of view, except Aravally Range and Hilly Region, all other regions also experience similar average rate of out-migration in Rajasthan. Among the five physiographic regions, the Semi-Arid region has experienced high average proportion of out-migration (7.3%); whereas Aravally Range and Hilly Region experienced low average rate (5.7%). Table 3 depicts that among the total out-migrants semi-arid plain (26.63%), Aravally Range and Hilly Region (24.50 %), and Eastern Plain (24.40%) regions were observed to have one third of out-migration.

In terms of mobility, every country, state or region has its own individuality of migration units (Tiwari, 1992). The concept of population regions is developed by different geographers from different views. Dube (1974), Smith (1928), and Chandna (1969) have given a brief description about the population regions. Tiwari (1992) used the population potential model and the composite scores method for the analysis of mobility regions (Table 4).

Mobility concentration regions or migration predominance regions are those regions which have experienced more than 7% out-migration to total population in Rajasthan (Figure 2). In Rajasthan, central and eastern districts have experienced high and very high rate of outmigration. Churu from Western Sandy Region; Sikar, Nagaur, Pali, Jhunjhunun from Semi-arid Plain; Ajmer, Rajaamand from Aravalli Range; Hilly, Dausa, Tonk, Sawai Madhopur, Karauli, Bundi districts from Eastern Plain; and Kota from Hadoti Plateau regions

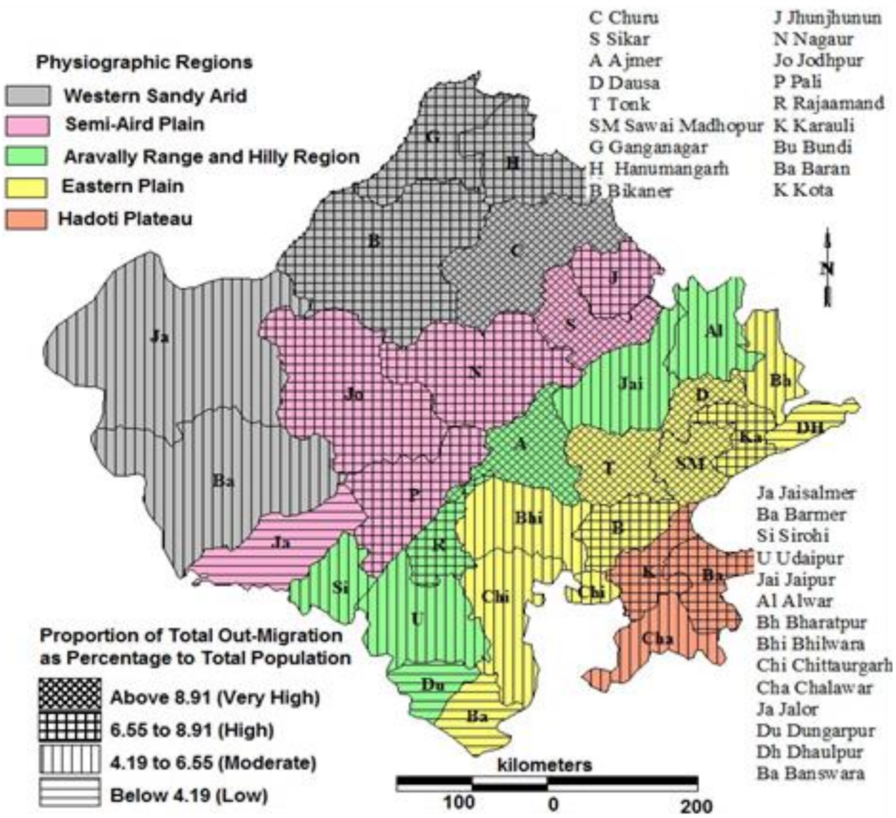

Figure 1. Inter-regional pattern of out-migration in Rajasthan, 2001.

Table 3. Region wise percentage share of total out-migration.

Regions	Average out-migration	Total out-migration	Region wise % of out-migration to total out-migration
Western sandy arid	6.81	647576	17.59
Semi-arid plain	7.3	980330	26.63
Aravally range and hilly	5.7	902123	24.50
Eastern plain	6.53	898283	24.40
Hadoti plateau	6.64	253080	6.87

Source: Census of India, Rajasthan, migration table: D-11: Persons born and enumerated in districts of the state.

Table 4. Migration concentration regions in Rajasthan, 2001.

Percentage of out-migration	Districts	Physiographic regions
	Churu	Western Sandy Region
	Jhunjhunun, Sikar, Nagaur, Pali	Semi-Arid Plain
Concentration of out-migration regions (Above 7.00%)	Ajmer, Rajsamand,	Aravalli Range and Hilly
	Dausa, Karauli, Sawai Madhopur, Tonk, Bundi	Eastern Plain
	Kota	Hadoti Plateau

Source: Census of India, Rajasthan, migration table: D-11: Persons born and enumerated in districts of the state.

experienced very high rate of out-migration that is, more than 7% out-migration to total population in the respective

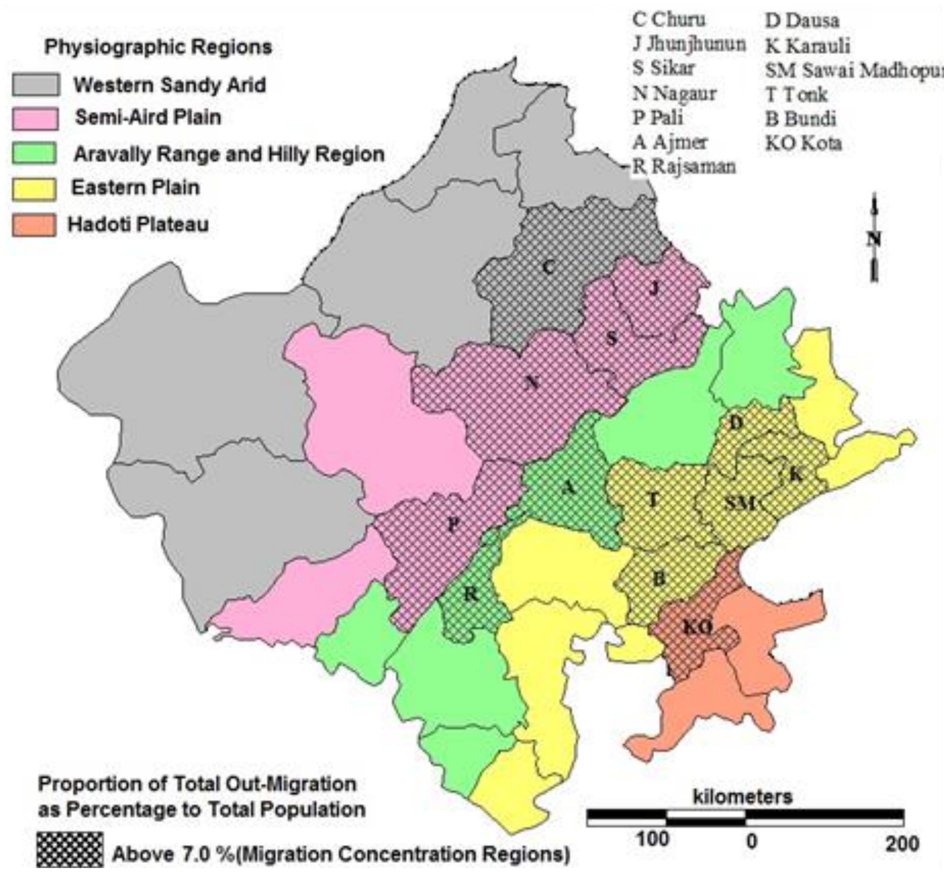

Figure 2. Concentration region out-migration in Rajasthan, 2001.

districts.

Balance of migration

Net migration means the difference between in-migration and out-migrants of an area in a specific period of time. Positive value means less out-migrant and more in-migrants; whereas negative value represents more out-migrants and less in-migrant.

Figure 3 shows net migration in different regions and districts in Rajasthan. Most of the parts of western sandy arid region, southern part and Jaipur from Aravally and hilly region and southern part of Eastern plain regions experienced positive migration balance.

The entire semi-arid plain and north-eastern part of eastern plain regions highlighted negative proportion of net-migration, meaning more out-migrants and less in-migration for absence of work opportunity for migrants.

Figure 3 shows an important pattern of net migration in Rajasthan. Western part and south-eastern part of Rajasthan observed positive rate of out-migration; whereas the entire middle portion of Rajasthan has observed negative rate of out-migration.

Inter-state male migration flow in Rajasthan

The people of Rajasthan have not only crossed district boundary but have gone beyond crossing the state too. Neighbouring states and UTs like Maharashtra (24.15%), Gujarat (21.46%), Delhi (12.52 %), Haryana (9.40 %), and Madhya Pradesh (7.90 %) received around 75.42% of all out-migrants from Rajasthan.

Figure 4 shows that the intensity and consistency of out-migrants is higher in the neighbouring states of Rajasthan compared to those states which are located far away. Maharashtra, Gujarat, Delhi, Haryana, and Madhya Pradesh are the neighbouring states of Rajasthan and these states have received 75.42% of the out-migrants who crossed the state boundary.

Among the total out-migration pattern from Rajasthan to the other states of India, high rate (above 7.51%) of out-migration was recorded in Maharashtra, Gujarat, Madhya Pradesh, Haryana and Delhi. Moderate rate (2.51 to 7.51 %) of inter-state of out-migration was found

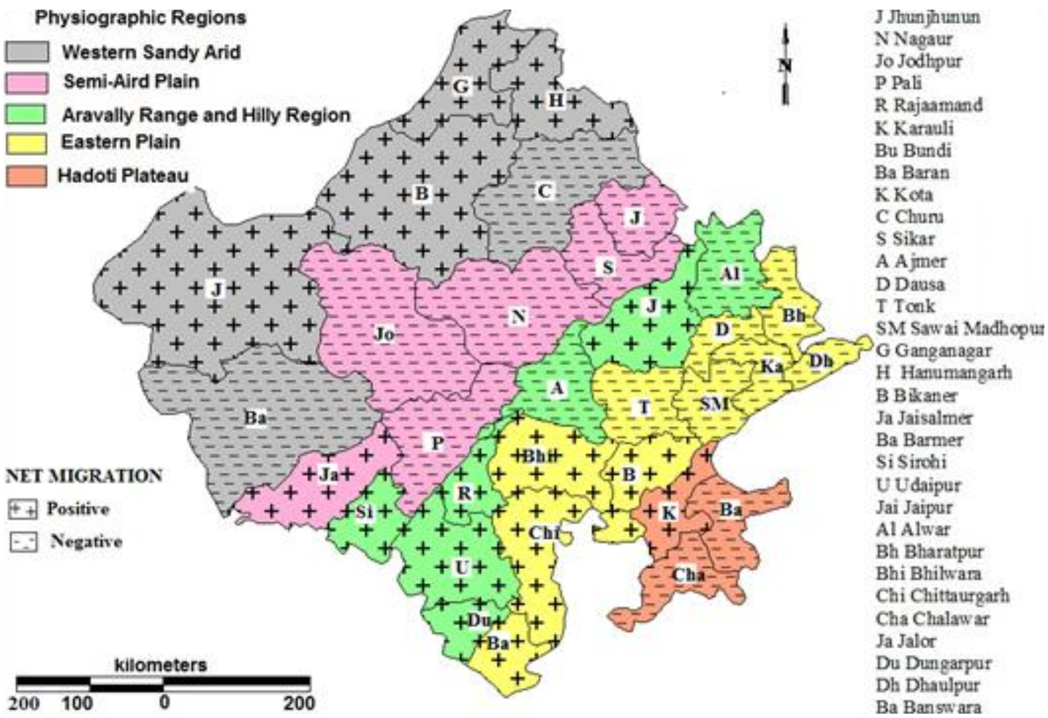

Figure 3. Positive and negative balance of migration, Rajasthan, 2001.

in Uttar Pradesh, Punjab, West Bengal and Tamil Nadu whereas the rest of the states and UTs received below 2.51% of all the out-migrants.

Premi (1980) suggested that in the case of short distance, females migrate more in rural areas whereas in long distance most of them migrate to the urban areas in search of work. Similarly, Piotrowski et al. (2013) said that short distance movements are likely to be marriage related while long-distance movements are probably work related.

In terms of inter-state outmigration, females dominate in short distance migration whereas males dominated in the long distance. Table 5 shows that Haryana, Punjab, Uttaranchal, UP, Bihar and Madhya Pradesh received greater volume of female migration. The rest of the states and union territories received large proportion of male migration from Rajasthan. Males generally migrate for work and employment purposes, and they moved to destinations that are economically and industrially developed offering greater employment opportunities.

Rajasthan also experienced a significant volume of in-migration from neighbouring state. Figure 5 depicts that neighbouring states and UTs like Uttar Pradesh (25.48%), Madhya Pradesh (15.09%), Punjab (13.03%), Haryana (11.26%) and Bihar (10.00%) received greater proportion of in-migrants into Rajasthan.

Figure 5 shows that the intensity and consistency of in-migrants is higher in the neighbouring states of Rajasthan compared to those states which are located far away. Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, and Bihar are the neighbouring states of Rajasthan and these states received 75.01% of the in-migrants who crossed the state boundary.

Conclusion

After the analytical study, it is clear that different physiographic regions have experienced diverse nature of out-migration. Except in the western part, the entire arid physiographic region and north-eastern part of eastern plain regions observed high propensity of out-migration.

In Rajasthan, central and eastern districts have experienced high and very high rate of out-migration. Churu from Western Sandy Region; Sikar, Nagaur, Pali, Jhunjhunun from Semi-arid Plain; Ajmer and Rajaamand from Aravalli Range; Hilly, Dausa, Tonk, Sawai Madhopur, Karauli and Bundi districts from Eastern Plain; and Kota from Hadoti Plateau regions experienced very high rate of out-migration to total population in the respective districts.

In terms of net-migration in Rajasthan, the Western part and South-eastern part of Rajasthan observed positive rate of out-migration whereas the entire middle portion of Rajasthan observed negative rate of out-migration.

Inter-state migration flow clearly proves that, distance

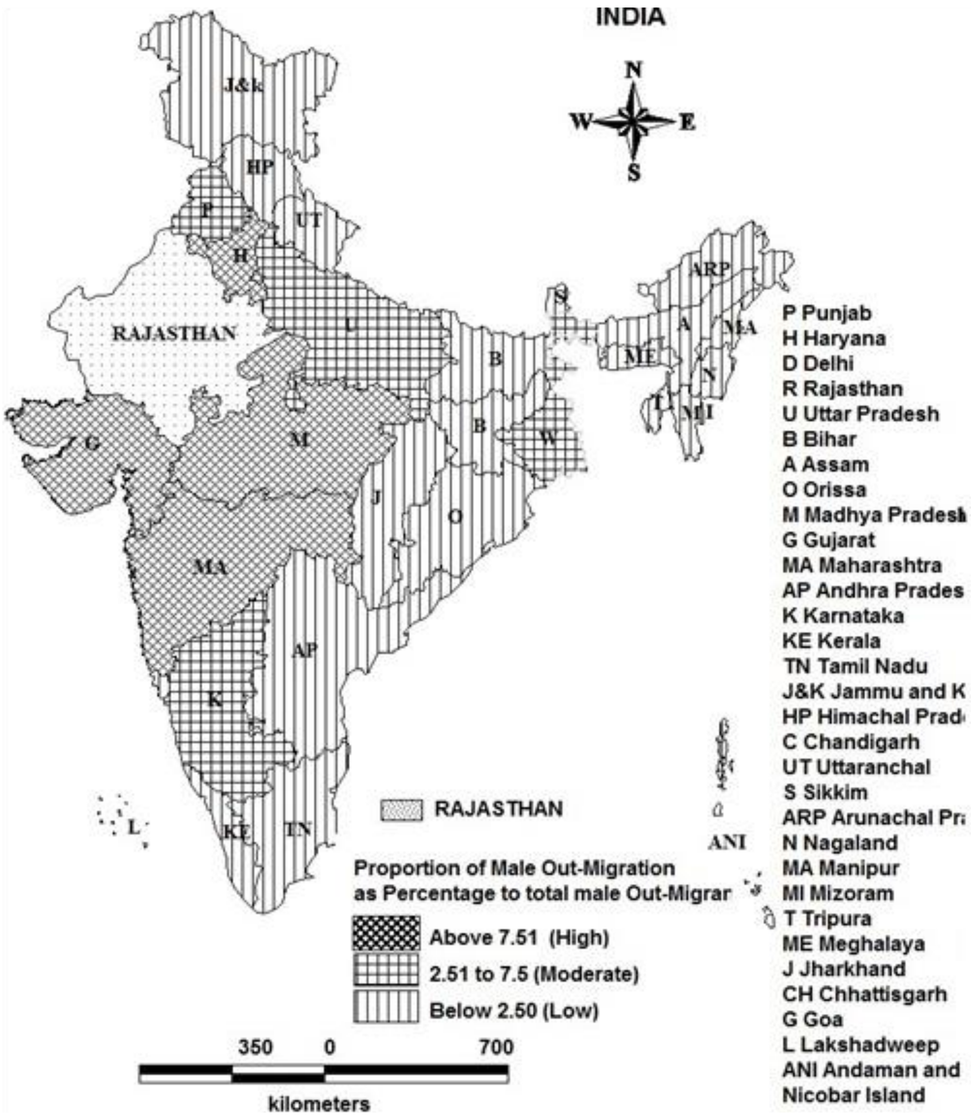

Figure 4. Inter-state male out-migration pattern from Rajasthan, 2001.

Table 5. Male-female destination flow of migration from Rajasthan, 2001.

Migration flow	Place of origin	State and union teritory (Place of destination)
Male dominated	Rajasthan	Delhi, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Jammu and Kashmir, Himachal Pradesh, Chandigarh, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Chhattisgarh, Daman Dui, Dadra and Nagar Haveli, Goa, Lakshadweep, Sikkim, Tripura Jharkhand, Assam, Orissa, Pondicherry, Andaman and Nicobar Island
Female dominated		Haryana, Punjab, Uttaranchal, UP, Bihar and Madhya Pradesh

Source: Census of India, migration table D-2: migrants classified by place of last residence, sex and duration of residence in place of enumeration.

creates little hurdle to migration; if the destination places are economically and industrially developed then distance does not matter. Maharashtra, Delhi, Gujarat, Punjab and Haryana are states that attract large

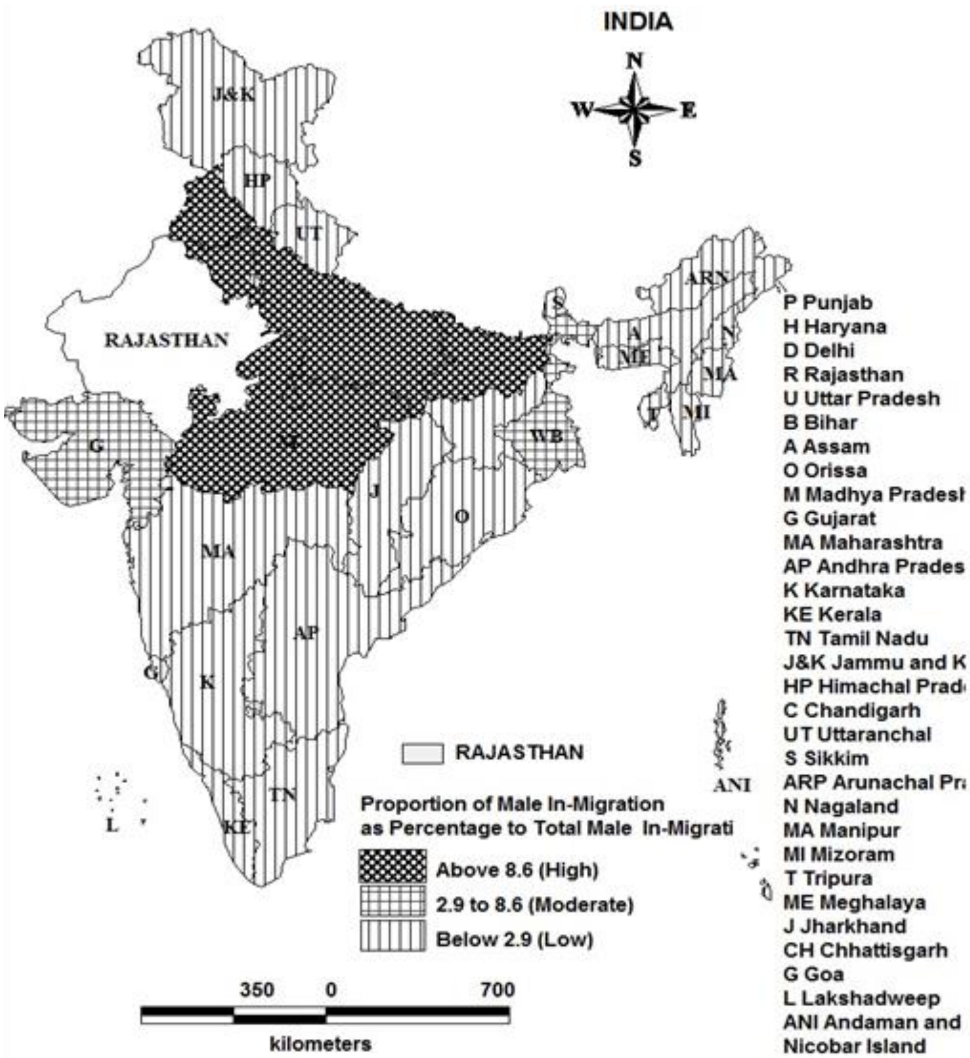

Figure 5. Inter-state male in-migration pattern in Rajasthan, 2001.

proportion of migrants from Rajasthan.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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