Electronic-Waste (E-Waste) Management and Minimization Practices: A Case Study of Dehradun District (Western Himalayan Region), Uttarakhand, India

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Abstract: The unprecedented generation of e-waste is a serious concern, which has become a critical environmental challenge across the world as well as considered as an emerging issue by policy makers, practitioners and researchers. The present paper deals with the case study conducted in four development blocks of Dehradun state (Doiwala, Sahaspur, Raipur and Vikasnagar) in Western Himalayan region from September 2020 to December 2021. We highlight standardized questionnaire based strategy including interviews of key stakeholders (Village head representatives, Education department, Development block officers, Representatives from Municipalities and Pollution Control Board) to evaluate present status of e-waste generation and awareness among communities. The results from the survey revealed that communities have low awareness level about e-waste management rules and regulations, its impact on environment and human health and formal and informal e-waste recycling processes. Besides, we organized training program to various stakeholders for making and repairing of LED bulbs, tube lights and creation of decorative sticks and bamboo carved lamps with respect to e-waste minimization and handling, which has resulted in providing a livelihood opportunity to the community. Folk media workshops (Short film, rap song, posters, leaflets, standees, puppet plays, street shows) were also organized together with launching of "EKU" (E-Waste Management and Minimization) campaign to spread awareness about systematic scientific management of E-waste in a simple and local language. Various e-waste minimization centers were established in Dehradun district on the basis of community recommendations. The study recommends that e-waste management, mitigation and recycling can be accelerated by promoting community awareness campaign, educating them about the benefits of scientific recycling of e-waste and making e-waste recycling as part of their livelihood source.

Keywords: E-waste management • Environmental Pollution • Public Health • Western Himalayan Region • Awareness Level

Introduction

Rapid technological revolutions have certainly changed our lifestyle, however, wide human dependency on Electrical and Electronic Equipment's (EEE's) such as cell phones, computers, video recorders, televisions, coffee machines, refrigerators and medical equipment that resulted in obsolescence of electronic products labelled as waste electric and electronic equipment (WEEE) or e-waste (Chauhan et al. 2018; Ahirwar and Tripathi, 2021).The toxic substances present in e-waste depend on the type of EEE's, for instance; cadmium and lead in circuit boards, lead oxide and cadmium in monitor cathode ray tubes, mercury in switches and flat screen monitors, cadmium in computer batteries, brominated flame retardants on printed circuit boards, and PVC cable insulation. Toxins produced during informal recycling such as polycyclic aromatic hydrocarbons, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans and various acids used for extracting metals such as HCl, H_2SO_4,

HNO_3, $HClO_4$, $NaClO$ are frequently released in the local environment, resulting in the increased level of toxic pollutants through leaching into soil and groundwater as well as releasing into surrounding air and surface water (Cesaro et al. 2019; Kumar et al. 2019).

Recent reports have estimated that globally, over 50 million tons (Mt) of e-waste was generated in the year 2019 (Andeobu et al. 2021) and it is estimated to exceed 74 million tons (Mt) by 2030 (Forti et al. 2020). India is included in the top 10 countries of the world concerning e-waste generation after the U.S. and China. Dumping of e-waste on Indian lands from foreign countries has also added the problem of E-waste generation (Ravindra and Mor 2019).In India, it is estimated that 3 million tons of e-waste were generated in 2018 (Andeobu et al. 2021).

The Himalayan regions encounter numerous environmental problems, thereby impacting mountain ecosystem to a great extent (Mushtaq et al. 2020). People living in mountainous regions are migrating to the cities for basic amenities and a better standard of living, but this has put the significant environmental challenge in the form of e-waste generation, leading to disturbance in the environment and jeopardizing public health. Uttarakhand, a newly formed Himalayan state is emphasizing and promoting growth of large and small businesses and has been witnessed to an abrupt increase in different types of waste generation including e-wastes. Hence, this study has considerable relevance as there is research gap with respect to the e-waste management and minimization and this study is first of its kind in depth until now in the Western Himalayan region of Uttarakhand state in India. We conducted a survey on e-waste awareness in Dehradun district. We collected data based on the resident's awareness on e-waste, which particularly included questionnaires about e-waste management and awareness. Based on survey response, we have established e-waste management and minimization centers where training has been given to various participants on different aspects of e-waste minimization. Also we have proposed a business model for creating a web portal and an android mobile app for e-waste management and awareness among people. Moreover, it is expected that this study will provide a better understanding of the importance of e-waste management, which is still in its beginning stage of implementation with respect to India and Uttarakhand state.

Material and methods
Brief description of study area

The Dehradun district of Uttarakhand state in Himalayan region was selected for this study. District Dehradun extends from N Latitude 29^0 58' to 31^0 02' 30" and E Longitude 77^0 34' 45" to 78^0 18' 30". The total area of Dehradun district is 3088 km^2 and having an average altitude of 640 m above MSL. Dehradun district generally comprises temperate climate. In Dehradun district, we have chosen four development blocks namely Vikasnagar, Sahaspur, Raipur and Doiwala. Sahaspur block is situated 25 KM far from Dehradun district headquarter. Various educational institutions are located in this block due to the availability of ample open space. Doiwala development block holds much of significance as it is centrally located amidst Dehradun, Haridwar and Rishikesh cities. Raipur block is located 8 KM towards East from district headquarter Dehradun. The Vikasnagar block is located 34 KM towards west from Dehradun District headquarters. In Fig. 1, location map showing four developmental blocks chosen for the study is depicted.
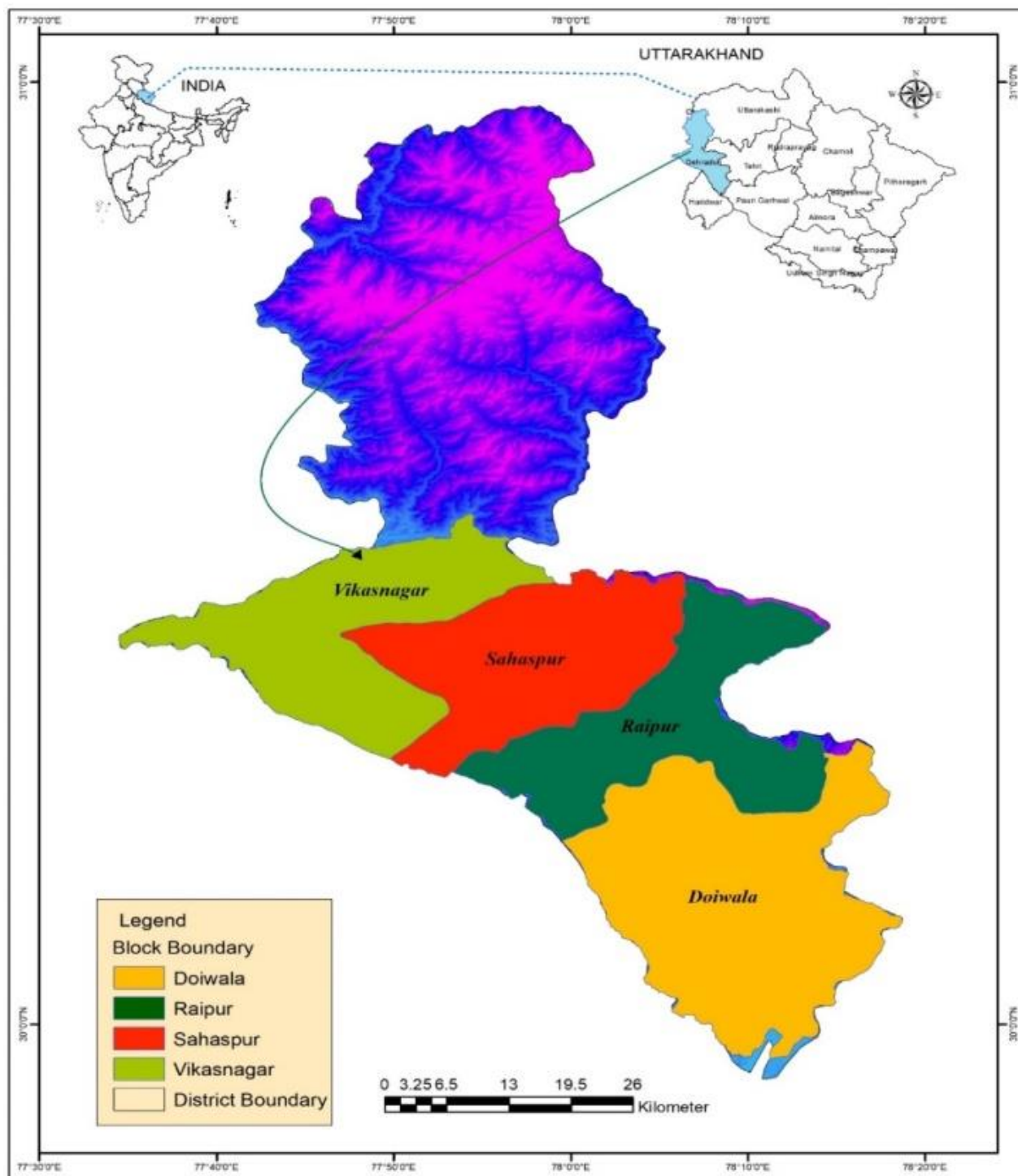
Fig. 1 Location map of study area

Methodology

Selection of research area

Data have been gathered in September 2020 to December 2021. However, during the second phase of the lockdown in 2021 due to COVID-19 pandemic, meetings and survey was reviewed through online mode. In Fig. 2, a detailed methodology has been demonstrated for the study.

(a) Designing of questionnaire

The study has undertaken baseline survey to know the present status of e-waste management in Dehradun district. This survey was carried out in two parts. In first part of the survey, people associated with the business of electronic and electrical goods including repair centers and scrap dealers were interviewed. The second part of the interview dealt with the people who use electronics items such as community leaders, local leaders, members of self-help groups and other officials. We asked questionnaire with two options for their answers, for instance; Yes, or No.Further, if the respondent's answer was Yes, then we further asked in details about e-waste recycling and management and their knowledge on this particular issue.Series of users meetings with line departments and stakeholders were organized in Dehradun district to understand the requirement of users, academicians, institutions and industries involved in e-waste business to develop and test the proposed methodology for training and future development action plans.

(b) Selection of e-waste collection centers

For this study, we organized meetings with the administrative units such as block offices, village development offices, compilation of the list of villagepanchayats including village heads,

list of departments working at village level, list of schools and colleges etc. Moreover, we gathered information from women's self-help groups, telephonic conversations were made and meetings were organized. Besides, contacts were also established with various departments through letters, e-mail, and messages etc. Due to Covid-19 pandemic, discussion related to the progress of e-waste centers was followed up over telephonic conversation and online meetings. The objectives of the survey were to know people's awareness of the guidelines issued by Government of India; how people are dealing with e-waste in their shop or home; how familiar people are with e-waste effects on environment and their health etc.

(c) Training on manufacturing and repairing of LED bulbs, tube light and bamboo lamps:

Trainings were provided under the program to the participants on:

- Making and repairing of LED bulbs and tube lights.
- Creation of decorative sticks and bamboo carved lamps.

(d) For developing web portal and mobile android app:

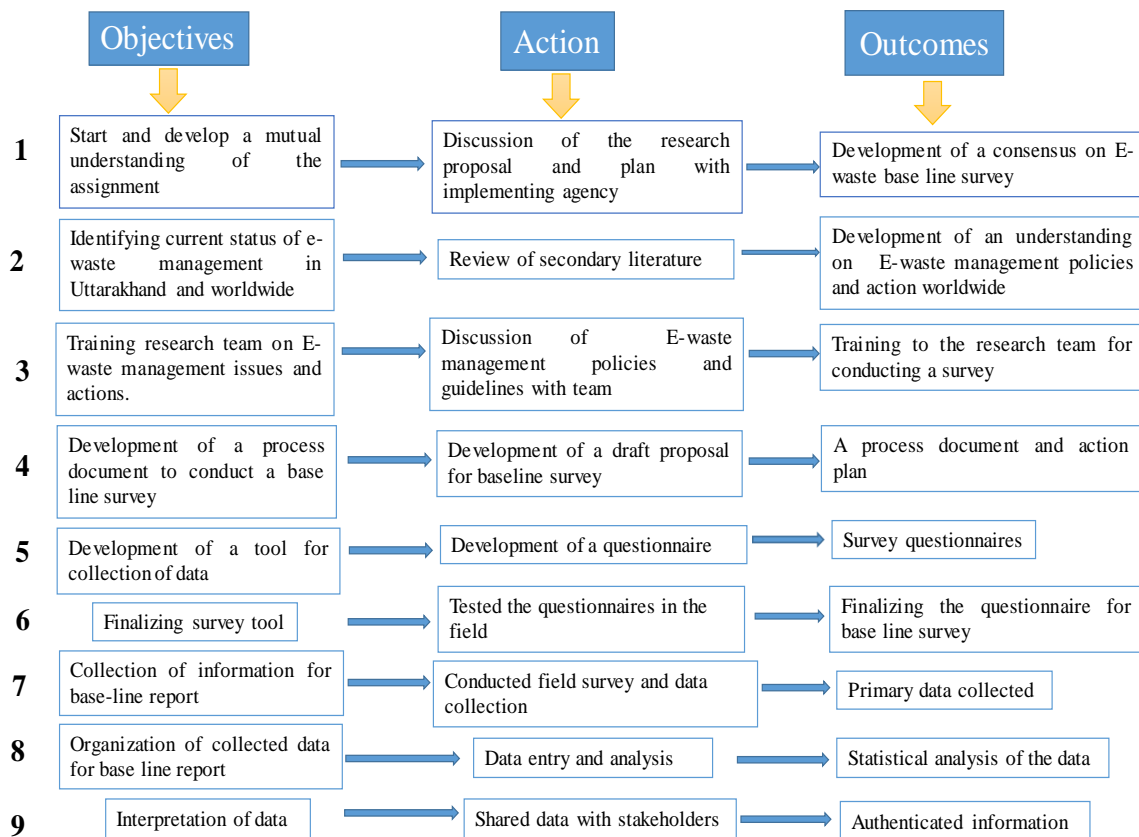For this, detailed methodology is given in Fig. 3.

Fig. 2 Detailed methodology used for socio-economic study of E-waste management and minimization
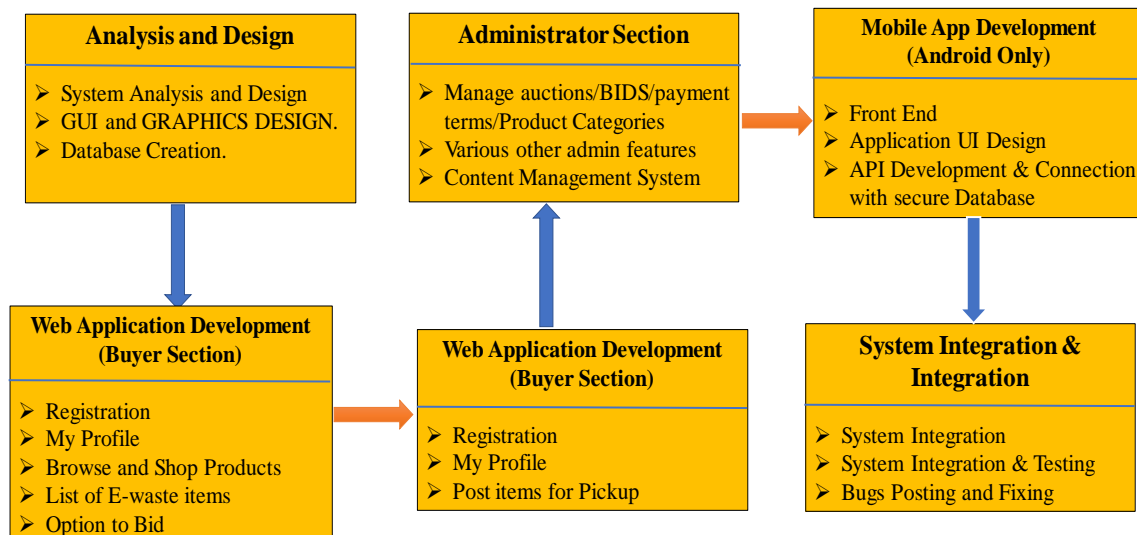

Fig. 3 Methodology for E-business model

Respondent's demographic information

Results and Discussions

This survey provides informative findings of the demographic profile of the respondents under study area in Table 1.

Table 1: Demographic profile of respondents (Census data, 2011)

Aspects	Doiwala	Sahaspur	Raipur	Vikasnagar
Total Population	22, 1513	18, 4381	165,386	165,663
Gender				
Male	11, 5070	96, 807	85,531	86,465
Female	10, 6443	87, 574	79,855	79,198
Total Households	46,200	37,778	35,424	31,638
Age Groups (years) were taken for the study	>18 years	>18 years	>18 years	>18 years
Occupation	Agriculture, Business, Students, Government job, Private job, Marginal workers	Agriculture, Business, Marginal workers, Students	Agriculture, Business, Students, Marginal worker, Government job, Private job	Agriculture, Business, Students, Marginal worker, Government job, Private job
Literacy				
Male	80%	77%	81%	70%
Female	68%	67%	73%	57%

Output from questionnaire

Knowledge and Awareness of e-waste management rules- 2016

We assessed the level of awareness among the scrap dealers and owners of repairing centers etc. The First hand data revealed that these aforementioned stakeholders have no knowledge of government's rules for electronic waste management. During the survey, it was found that no respondent was aware of the e-waste management rules 2016 in all selected study sites (Table 2). This shows gap between the Government's inputs to enforce the laws and consumer's awareness with respect to aforementioned law.

Arrangements for collection of e-waste

During the survey, we could not see single shop and repair centers with box, bin or a demarcated area. Majority of the respondents agreed to deposit their e-waste to the nearby collection centers. Presently, they either sell it to the scrap dealers or dump it. The survey results depicted in Table 2indicate that only 10% of respondents in Sahaspur and 3% of respondents in Vikasnagar were found to have arrangements for the collection of e-waste at their premises. In Doiwala and Raipur blocks, no arrangements for e-waste collection have been observed.

Awareness about the impact of e-waste on environment

During the survey, it was found that maximum respondents were concerned about the environment, however, they seem unaware about how does e-waste impact the environment. The survey result found that only 23% respondents in Doiwala and Sahaspur while 33% respondents in Raipur and 17% respondents in Vikasnagar were aware about the impact of e- waste on environment (Table 2).

Awareness about the impact of e-waste on human health

It was found during the survey that e-waste is left in the shops and repair centers for many days. Most of the respondents were not aware about the harmful chemicals and radiation which are emitted from the e-waste. The respondents generally treat e-waste as normal solid waste.

Only 17% % respondents in Doiwala, and Sahaspur, while 23% of respondents in Raipur and 20% respondents in Vikasnagar know the negative impact of e-waste on human health while 80 % respondents were not aware of negative impacts of e-waste on human health (Table 2).

Awareness about the negative impact of e-waste on environment

The survey data revealed that in Doiwala, only 10% of people, 16% in Sahaspur, while 17% in Raipur and Vikasnagar blocks were aware of the negative impact of e-waste on the environment while 93% people either did not know about the impact of e-waste on environment or they do not find any harm through the e-waste in the environment (Table 2).

Awareness about e-waste

The survey data showed that only 13 % respondents in Doiwala, 14% respondents in Sahaspur while 10% respondents in Raipur were aware about e-waste. Unfortunately, in Vikasnagar, no individual person has an awareness about e-waste (Table 2).

Management of e- waste at home

The survey data revealed that 40 % people in Doiwala, 70% in Sahaspur, and 24% in Raipur give their e-waste to the scrapers. Around 7% people in Doiwala, 3% in Sahaspur, and 4% in Raipur burn their e-waste. In Vikasnagar, neither they burn it nor sells to the scrapers. Further, 36% in Doiwala, 24% in Sahaspur, 10% in Raipur while 17% in Vikasnagar, people throw/dump their e-waste to nearby dumping areas(Table 2). The respondents believed that if there would be any nearby management unit for the collection of e-waste, then they are ready to give their household e-waste to collection centers. Presently, they don't have perfect choice and information to give the e-waste for re-cycling process.

Selection of e-waste collection centers

After organizing meetings with participants, e-waste collection centers were selected based on the priorities of participants under which the listed areas were selected in Dehradun (Table 3). We also conducted various activities being done in the previously established e-waste minimization centers and provided them necessary support. Public participation was the foremost aspect of establishing e-waste collection centers. By conducting meetings and to make community aware about their participation to establish e-waste collection centers. All these meetings were helpful in strengthening the roots of these ideas and maintaining their presence in the public. Furthermore, in Dehradun city, people generally don't want to go the centers for dumping of e-waste. By keeping the busy schedule of people in consideration as well as based on their convenience, 60 e-waste collection centers were established in 60 wards of Dehradun city under **"EKU Campaign"**. These centers are equipped with bins and awareness material and 60 e-waste watchdogs (locally called as "Praharis") are also present at each center. In figure 4, established e-waste minimization centers are shown in map. In table 4, we have mentioned all established e-waste collection and minimization centers in Dehradun district.
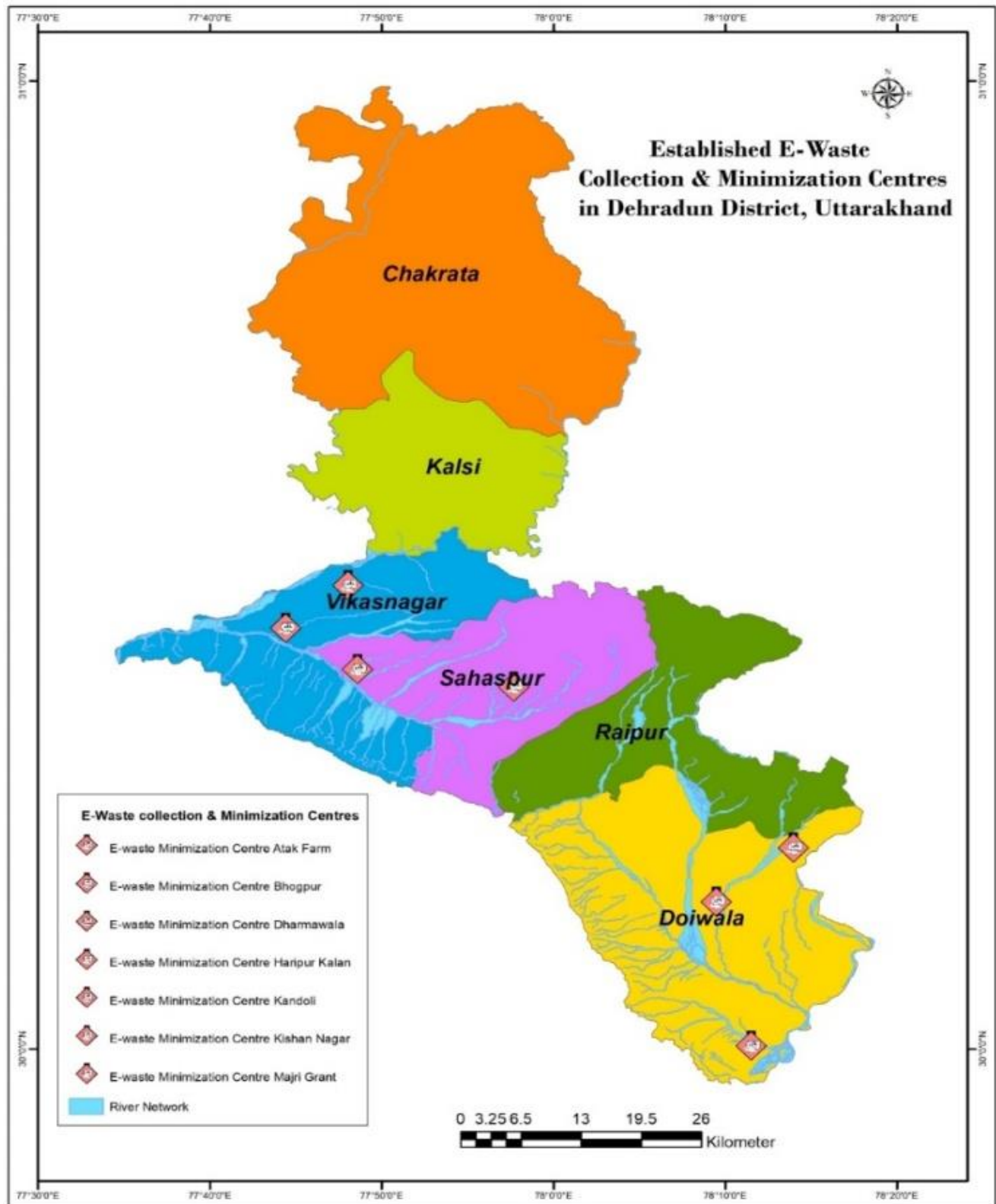
Fig. 4 Established E-waste collection and minimization centers

Table 2 Survey questionnaire

Variables	Code	Question	Response								Total
			Yes				No				
			Doiwala	Sahaspur	Raipur	Vikas	Doiwala	Sahaspur	Raipur	Vikas	
Awareness	A1	Are you aware of e-waste management rules-2016	0%	0%	0%	0%	100%	100%	100%	100%	100%
	A2	Do you have any arrangement for e-waste collection at your premises?	0%	10%	0%	3%	100%	90%	100%	97%	100%
	A3	Do you aware about the impact of e-waste on environment?	23%	23%	33%	17%	73%	77%	67%	83%	100%
	A4	Do you aware of negative impact of e-waste on Human health?	17%	17%	23%	20%	83%	83%	76%	80%	100%
	A5	Do you know about e-waste?	13%	14%	10%	0%	87%	86%	90%	100%	100%
	A6	Do you aware of negative impact of e-waste on environment?	10%	16%	17%	17%	90%	84%	83%	83%	100%

Variable	Code	Question	Response (%)															
			Selling to Scrapers				Burning				Throwing				Cannot say			
			Doi	Sahas	Rai	Vikas	Doi	Sah	Rai	Vik	Doi	Sah	Rai	ViK	Doi	Sahas	Rai	Vikas
Management	A7	How do you manage e-waste	40%	70%	24%	0%	7%	3%	4%	0%	36%	24%	10%	17%	3%	3%	62%	83%

Variable	Code	Question	Response								Total
			Yes				No				
			Doi	Sahas	Rai	Vikas	Doi	Sah	Rai	Vik	
Management	A8	Do you segregate the e-waste?	10%	7%	7%	7%	90%	93%	93%	93%	100%

Table 3: Established E-waste collection and minimization centers in Dehradun

S.N.	Established e-waste minimization center at various places of Dehradun district
1	PanchayatGharResham, Majri (Doiwala)
2	E-Waste Collection and Minimization Centre, Bhogpur (Doiwala)
3	E-Waste Collection and Minimization Centre, Haripur Kalan (Doiwala)
4	E-Waste Collection and Minimization Centre, AtakfarmTelpura (Sahaspur)
5	E-Waste Collection and Minimization Center, Lower Kandoli (Sahaspur)
6	E-Waste Minimization Center, Dharmawala (Vikasnagar)
7	E-Waste Minimization Center, Krishna Nagar (Dehradun city)

E-waste minimization and management awareness campaign through various mediums

Main aim of the campaigns was to aware people about e-waste, its minimization, repairing, manufacturing and reuse. This campaign focused on those devices that run though electricity as well as batteries such as electric bulbs, lamps, tube lights, chargers, batteries, mobiles etc. These devices should not be thrown away as garbage, rather, many of these devices can be repaired at a very low cost, which isnot known to everyone. A number of people and groups (Self Help groups) who were trainees under e-waste campaign approached to set up e-waste centers at their places, which clearly shows the positive outcomes from our e-waste campaign. Table 4 illustrated the areas where we conducted campaigns to promote e-waste management.

(a) Awareness through printing media

Being a hilly state (Uttarakhand), an e-waste management is completely new concept for the community living here, thus it is more challenging to make community aware about e-waste. Through the medium of printing, pamphlet has been prepared and provided with important information about

e-waste in simple words. The pamphlet contains information such as-

- Publicity by making community aware about the economics of e-waste.
- Developing skills through local resources.

(b) Awareness through digital medium and radio

We also used digital medium for publicity as it leaves long lasting impact on the people. The information about e-waste was communicated through rap song, folk song and a short skit. All India Radio (AIR) and OHO radio were also our partners to publicize e-waste awareness campaigns through their digital platforms.

(c) Awareness through traditional medium

Short Street plays linked with e-waste was organized under this campaign. Taking into account COVID-19 scenario, we were ensured social distancing in the communication process. Later, we decided to utilize the script of short street plays for making short movies and using social media platforms such as Facebook, YouTube, Instagram and WhatsApp for their screening.

(d) Awareness through puppets

Since time immemorial, puppets are known for creatively conveying education and messages. Rod puppets and glove puppets were used in this campaign. Discussions were executed regarding repairing and collection centres of e-waste which is being run by various developmental blocks of Dehradun, also women respondents were target during mass discussion group for the promotion of e-waste minimization centres set up at all four development blocks.

- Setting up of entrepreneurship opportunities through e-waste management wellness chain.
- Capacity building regarding recycle, reuse and repair regarding e-waste management.

(e) Awareness through social platform

Social media promotion of developed android mobile app and e-waste and its management awareness campaigns were conducted through various social-networking sites such as Facebook, YouTube, Instagram and WhatsApp.

Innovations accomplished during study

Innovation is the practically useful implementation of ideas or thoughts that results either in the introduction of new merchandise/services or up-gradation in goods or services. This study has achieved success in managing e-waste to a large extent by developing income generating enterprises during the time of COVID-19 pandemic to the local community. Maximum amount of e-waste was minimized by repairing of large number of LED bulbs. The discarded bulb was reused by the community and saved their money and they were able to reuse them with great satisfaction. Therefore, efforts were made to save e-waste from being dumping into the bins of the city which is a great contribution towards saving environment.

Table 4: Various campaign (hands-on training, street plays, awareness lectures) carried out in various locations of Dehradun district

S.N.	Location	Area
1.	Block Office Vikas Nagar	Vikas Nagar
2.	Fatehpur GPS, Vikas Nagar	Vikas Nagar
3.	Dharmawala GPS, Vikas Nagar	Vikas Nagar
4.	Prateetpur Shiv Mandir, Vikas Nagar	Vikas Nagar
5.	Baluwala, Vikas Nagar	Vikas Nagar
6.	Kedarwala, Vikas Nagar	Vikas Nagar
7.	Bulakiwala CSC Center Telpura, Vikas Nagar	Vikas Nagar
8.	Etan Baag Panchayat Bhawan, Vikas Nagar	Vikas Nagar
9.	Mehuwala Panchayat Bhawan, Vikas Nagar	Vikas Nagar
10.	Banso Wala Shiva Temple, Vikas Nagar	Vikas Nagar
11.	Shahpur Kalyanpur \ Panchayat Bhawan, Vikas Nagar	Vikas Nagar
12.	Vikas Nagar	Vikas Nagar
13.	Dhakrani, Vikas Nagar	Vikas Nagar
14.	Doon Valley Public School JeevanGarh, Vikas Nagar	Vikas Nagar
15.	Dhakrani Ward No. 9, Vikas Nagar	Vikas Nagar
16.	Dharmawala E-Waste Collection Centre, Vikas Nagar	Vikas Nagar
17.	Shiv MandirMehuwalaKhalsa, Vikas Nagar	Vikas Nagar
18.	LakhanWala	Vikas Nagar
19.	Majri Grant Sherpur Kalas Tar Bhawan	Doiwala
20.	Bhogpur E-Waste Centre	Doiwala
21.	Haripur	Doiwala
22.	Kalu Siddha	Doiwala
23.	Laxman Siddha	Doiwala
24.	Birla Farm Haripur	Doiwala
25.	Prem Vihar Basti, Doiwala	Doiwala
26.	Dhaki Panchayat Bhawan, Sahaspur	Sahaspur
27.	Selaki Jabhavpur, Sahaspur	Sahaspur
28.	Sanatan Dharma Arya Inter College, Sahaspur	Sahaspur
29.	Library Check Mussoorie, Sahaspur	Sahaspur
30.	Nanda ki Chowki, Jhajra Basti, Jamanpur Basti, Sahaspur	Sahaspur
31.	Parwal Village, Sahaspur	Sahaspur
32.	Muslim Basti Shimla by Pass, Sahaspur	Sahaspur
33.	Kalabari Grant, Sahaspur	Sahaspur
34.	Pondha Government Inter College, Sahaspur	Sahaspur
35.	Rajkiya Madhyamik Vidyalaya, Pondha, Sahaspur	Sahaspur
36.	Dhool Kot, Sahaspur	Sahaspur
37.	Sudhowala Jail, Sahaspur	Sahaspur
38.	Junior High School, Kandoli, Sahaspur	Sahaspur
39.	Sunrise Academy, Raipur	Raipur
40.	Aamwala Tarla Ambedkar Basti, Raipur	Raipur
41.	Chor Khala	Dehradun
42.	Doon Zoo Municipal Corporation	Nagar Nigam
43.	Municipal Corporation	Nagar Nigam
44.	Vijay Colony E-Waste Minimization Center	Nagar Nigam
45.	Kanwli Village E-Waste Center Minimization Center	Nagar Nigam

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Moreover, during Diwali festival, decorative lights are purchased by the people, which are thrown into the dustbins after one use or so. Under this campaign, we repaired the waste decorative lights along with the training program to the community. Therefore, maximum numbers of people were able to celebrate the festival of lights in a very economical way. This was an occasion based innovative approach. In addition to this, we have made new LED bulbs, tube lights, bamboo lights, decorative lights and beautiful and attractive customized hand painted bottle lamps. These quality products are available at a very reasonable cost of 40% less than the market. Under these activities, waste glass bottles were also collected, washed, dried. We reused them after inserting LED bulbs and hand-painted them with beautiful and magnificent designs. Waste bottles had turned into an elegant lamp by increasing its value 100 times more than before.

Cost Analysis

The cost of a fused bulb repairing is INR 1.32 and its weight is approximately less than 1 gm. Weight of a bulb is generally 47 gm. Cost of repairing of a single bulb is INR 22. Therefore, if 614 bulbs were repaired in Doiwala and Sahaspur areas, then approximately 28244 gm or 28.24 kg (weight of 1 bulb i.e. 46g x 614) e-waste generation was minimized. About INR 70610 were saved (Rs. 115 per bulb) in repairing of 614 bulbs. Moreover, 750 bulbs were repaired at Pacific Estate of Dehradun city, therefore (46g x 750) approximately 34500 gm or 34.50 kg e-waste generation was minimized and about INR 86250 were also saved. Thus, a total of (28.24+34.50) 62.74 kg e-waste generation was minimized and therefore, approximately INR 1, 56, 860 were saved during this study period. This innovation has helped in for minimization of pollution free environment. In Table 5, we have calculated estimation of total e-waste reduction through LED bulb repairing in Dehradun district.

Table 5: Estimation of total e-waste reduction through LED bulb repairing activity

Area	Total LED bulbs repaired	Saving of E-waste in (Kg)	Total Saving in (INR*)	Cost Saving of Customer after repairing (INR)*
Doiwala and Sahaspur	614	28.24 Kg	70610	57102
Dehradun	750	34.50 Kg	86250	69750
Total	**1364 bulbs**	**62.74 kg**	**1, 56, 860**	**1,26,852**

Income generation

During survey, income generation from all established e-waste collection centers was calculated in Table 6. It was estimated that Doiwala and Sahaspur area manufactured 3244 LED bulbs, sold 2063 LED bulbs, repaired 614 LED bulbs, manufactured 91 hanging LED, sold 81 hanging LED, made 1220 decorative lights and collected 335 e-waste devices. In Vikasnagar area, 32 bulbs, 32 LED fairy lights and 64 bamboo lamps were prepared by the community. Additionally, 2000 fairy lights were also made during festive season of Diwali. Total number of LED bulbs repaired by the organization during the time period of the

project at various places is shown in Fig. 5. Total number of LED bulbs manufactured and sold at various e-waste minimization centers is shown in Fig. 6. Total number of fairy lights manufactured and sold at various e-waste minimization centers is shown in Fig. 7. Total number of e-waste devices collected at various centers is shown in Fig. 8.

Table 6: **Income Generation by E-waste Collection Centers**

Cost of manufactured L.E.D bulbs (INR)	Income from sale of L.E.D bulbs (INR)	Income from repairing L.E.D bulb (INR)	Cost of manufactured decorative bamboo lights (INR)
210860	134095	13508	350000
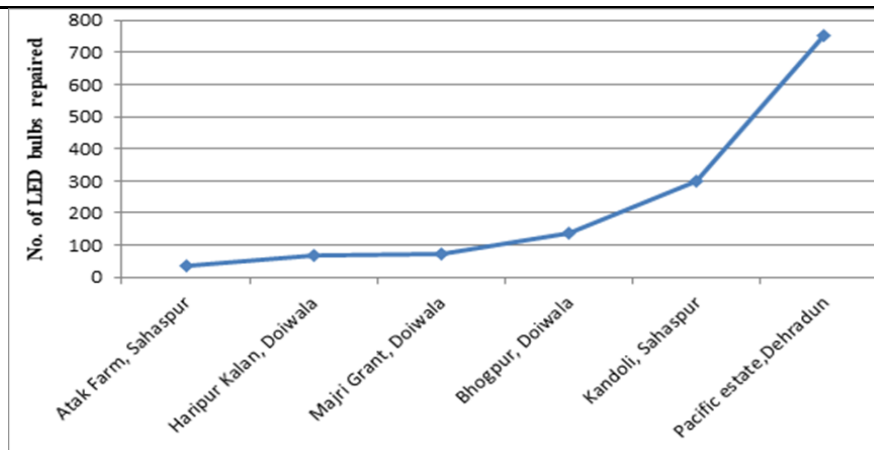
Fig. 5 Total number of LED bulbs repaired during the study
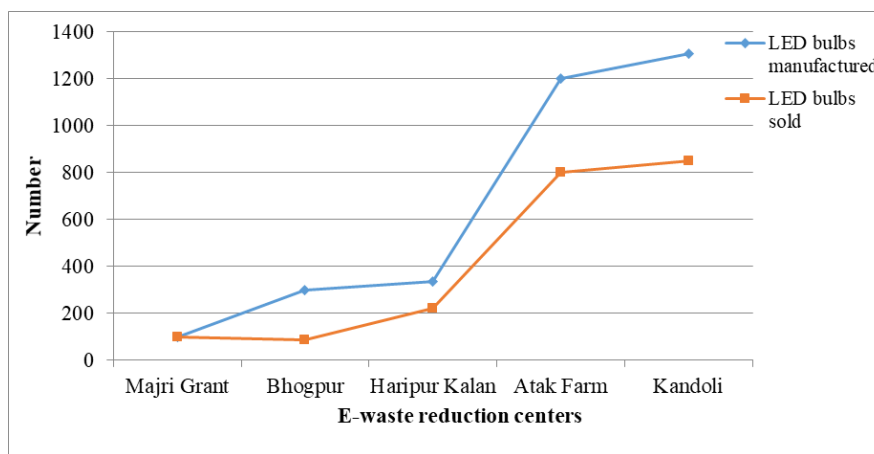
Fig. 6 Total number of LED bulbs manufactured and sold at various centers
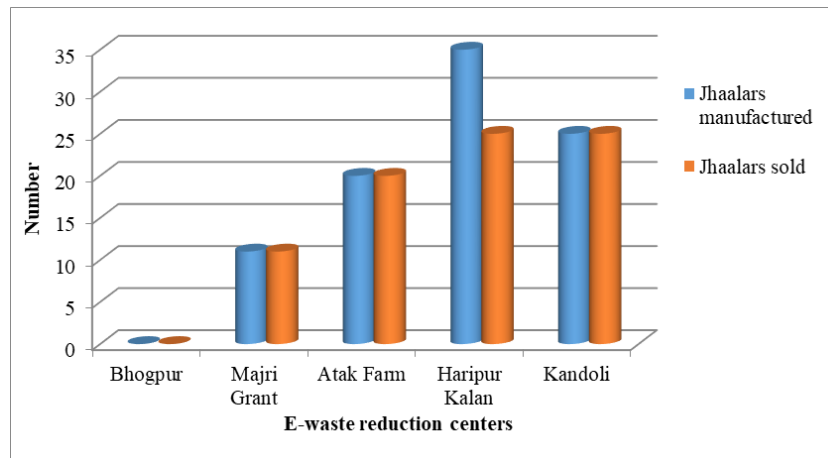
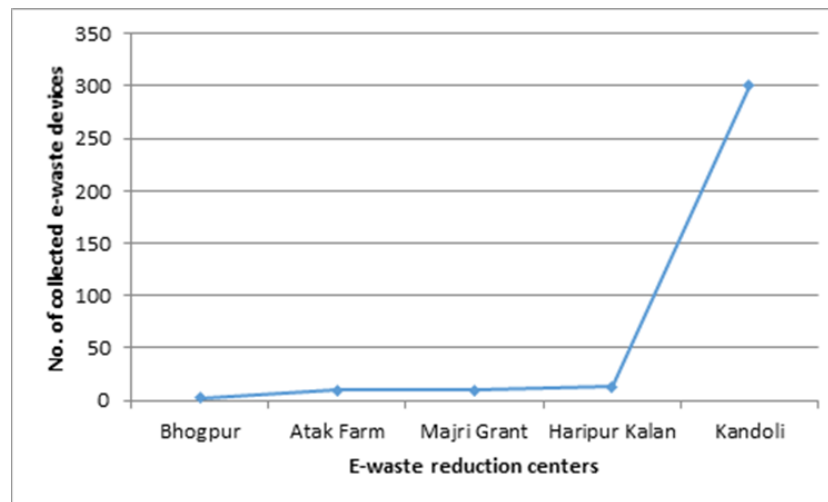**Fig. 7 Total number of fairy lights manufactured and sold at various centers**

Fig. 8 Total number of e-waste devices collected at various centers

Development of android mobile app/business model

Before starting this project there was not any existing platform in Uttarakhand, where people can Sell/Donate and get repair their unused electronic items. The android mobile app has been developed and it has been field tested at our study areas with the stakeholders to give them an insight about the overall working mechanism. Additionally, this App has been successfully released on Google Play Store and everyone can download it very easily. Presently, people of Uttarakhand can Sell, Donate and also repair their electronic items on request to their nearest e-waste collection and repairing centers

by recent developed e-waste management Uttarakhand android application. These centers are geo tagged and listed in this android application. Our main aim is to connect our all established e-waste collection centers to the large e-waste buyer companies for systematic and scientific collection of e-waste. The profit from selling of e-waste to the companies through the app will be directly benefit the stakeholders (local community), thus providing them economic support too. Following achievements have been accomplished during the study:

➢ We have developed Seller module in E-waste Management Uttarakhand Android mobile app for end user for

collection and repair of E-waste from Uttarakhand (Dehradun and Rudraprayag District).

➢ We have developed Buyer module in e-waste Management Uttarakhand Android app for the buyers who have to buy all collected E-waste by the E-waste collection centre through Seller module of E-Waste Management Uttarakhand Android App.

➢ We have developed a stand-alone app for poor network area in which E-waste collection centre's admin can record all data of collected E-waste without any network availability when the system gets any internet network then data will upload on the server automatically.

➢ We have development of E-Waste Management Uttarakhand website (www.ewasteuttarakhand.com).

Conclusion

Results of the questionnaire-based survey and users meeting revealed the lack of awareness about e-waste, its segregation and associated impact on health and environment. Establishment of e-waste collection centers at various places with respect to management and minimization of e-waste to a large extent helped the surroundings from e-waste pollution and can be helpful in mitigating environment pollution in future. Moreover, hands-on training programs on LED bulb repairing and discarded e-waste has opened new dimensions of employment for local community even during the pandemic (COVID-19) period. Besides, quality products were supplied to the people at nominal cost as well as ensuring income generation together with e-waste minimization in the area. During our awareness campaign, various institutions voluntarily joined us with respect to mitigate e-waste and we are planning sign a MoU with a schools, institutions, universities and banks to

minimize E-waste. All established e-waste collection and minimization center's geo-tagging was done by e-waste management Uttarakhand android app's development team and these centers are successfully mapped in the e-waste management Uttarakhand android application that will be helpful to users automatically detect their nearest e-waste collection/repairing center. With this existing data, concerned Government and its regulatory bodies can adopt proper implementation strategy to supervise the e-waste generation and concerned recycling processes. Further research and analysis in details are needed to analyze inadequacy in existing laws and policies to better address e-waste awareness campaign among stakeholders. We also recommend to execute the research in other cities of Uttarakhand to get a detailed database on e-waste generation.

Acknowledgement

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