

Research Article

Design, Construction, and Evaluation of the Performance of Dual-Axis Sun Tracker Parabolic Solar Cooker and Comparison of Cooker

Solomon Tibebe ^{1,2,3,4} and Arkbom Hailu ^{1,2}

¹Department of Environmental Engineering, College of Biological and Chemical Engineering, Addis Ababa Science and Technology University, Addis Ababa, Ethiopia

²Sustainable Energy Center of Excellence, Addis Ababa Science and Technology University, Addis Ababa, Ethiopia

³Bioprocess and Biotechnology Center of Excellence, Addis Ababa Science and Technology University, Addis Ababa, Ethiopia

⁴Environmental Protection and Green Development Commission, Addis Ababa, Ethiopia

Correspondence should be addressed to Solomon Tibebe; solomon.tibebe@aastu.edu.et

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Energy demand is increasing due to population increment and industrialization. To meet this energy demand, technologies that use renewable energy such as solar energy are being developed. A parabolic solar cooker is one of the main solar cookers, which can cook food and boil water at a high temperature within a short period. This study aimed to design, construct, and evaluate the performance of the constructed parabolic solar cookers. Moreover, this study aimed to compare the constructed cooker with firewood, charcoal, kerosene, and electricity in terms of cooking time and energy cost. The cooker was constructed using different materials such as old satellite dishes, tyres, steel, and aluminum foil. The aperture diameter, aperture area, receiver diameter, receiver area, depth of the parabola, focal length, rim angle, circumference of the circle, surface area, length of the circumference, and concentration of the cooker were 1.8 m, 2.54 m², 0.16 m, 0.02 m², 0.3 m, 0.67 m, 67.38°, 5.76 m, 2.81 m², 5.76 m, and 123.46, respectively. The cooker can track the sun from north to south and from east to west. The performance of the cooker was evaluated by calculating the efficiency and power. The output energy, input energy, and average upcoming solar radiation of the constructed parabolic solar cooker were 0.182 kW/m², 1.691 kW/m², and 0.665 kW/m², respectively. The efficiency and power of the cooker were 10.75% and 0.3 kW/hr, respectively. The constructed parabolic solar cooker relatively showed better performance in cooking different foods. A family, which has five members, was considered to compare the constructed cooker with other fuels in terms of energy cost of cooking. Since the parabolic solar cooker does not have any energy cost, it can save the energy cost of cooking foods. Therefore, parabolic solar cookers have a great advantage for developing countries including Ethiopia.

1. Introduction

Energy is one of the necessities to live on this planet [1, 2]. Plants use energy to prepare their food, humans use energy to cook their food, and industries use energy to manufacture

different products [3]. In early times, energy is completely harnessed from fossil fuels (coal, oil, and natural gas). As humans become more civilized, their industries also grow, which in turn increased energy demand. The rapid increment in population also contributed to the increment of

energy demand [4–6]. This caused an increment in the utilization of fossil fuels. Eventually, this started to degrade the environmental quality [7]. Global warming, which is caused by the increase in the concentration of greenhouse gases in the atmosphere due to the burning of fossil fuels, causes the increment of the earth's mean temperature [8, 9]. This in turn causes climate change, which is responsible for different hazards such as floods and drought [10]. The burning of fossil fuels also causes acid rain, which can cause an adverse impact on forests, freshwater, and soil [11]. The fluctuation and increment of fossil fuel prices were also the other problems that affected countries, whose economy depends on nonrenewable energy [12]. Moreover, according to Hafner and Tagliapietra [13], after a few hundred years, all fossil fuels in sub-Saharan African countries will be extracted.

To solve the above problem, in addition to energy conservation, researchers started to study more about alternative energy resources such as solar, wind, hydro, geothermal, tidal, and biomass, which are commonly called renewable energy [14–17]. These energy sources are clean and environmentally friendly. Green energy (renewable energy) plays an important role to have affordable, accessible, and reliable energy for all [18]. Renewable energy diversifies the energy source and reduces the utilization of fossil fuels [19, 20]. Unlike solar energy, most renewable energy sources require high technological advancement for installation and operation [21]. Therefore, solar energy is a preferable energy source for developing countries including Ethiopia [22–24].

Solar energy has the potential to become the primary energy source in all Africa countries [25]. This is mainly due to the high solar intensity reaching the earth's surface [26]. Also, these countries get solar energy for a longer period throughout the year [27]. According to Griffiths [28], most of the continent enjoys sunshine for a longer season per year. Due to the spherical shape of the earth, the surface of the earth will not get uniform solar radiation [29]. Countries such as Ethiopia, which are located near the equator, can get a bigger advantage from this energy source because of the high solar intensity. According to Khadem et al. [30], the annual average daily radiation on a horizontal surface in Ethiopia is 3.74 kWh/m^2 with a minimum of 1.5 and a maximum of 4.9 kWh/m^2 . We can use solar energy for different purposes such as generating electricity, boiling water, and cooking food [31].

Nearly 730 million people in sub-Saharan Africa countries rely on biomass as a primary energy resource [32]. Among the different types of biomass, most African countries utilize firewood, which indicates that deforestation is a big problem in this continent [21]. In Ethiopian rural areas, firewood is the main source of energy, but in cities, electricity, kerosene, and charcoal are the main sources [33].

In Ethiopia, over 80% of the population utilizes biomass as a primary source of energy [34]. According to Overend [35], the main reason for the consumption of biomass in sub-Saharan countries is for cooking purposes. In most developing countries, there is a shortage of firewood due to the high consumption of energy and cooking in an inefficient stove in a poorly ventilated

space [36]. Cooking food requires firewood gathering and frequent attention to make sure the food cooks evenly. Moreover, when women and children collect firewood for cooking and other purposes, they may face sexual harassment such as rape, unwanted pregnancy, psychological problem, and sexually transmitted diseases [37]. Utilizing charcoal in poorly ventilated spaces can cause a serious respiratory problem due to the emission of carbon monoxide and other gases [38]. Kerosene is expensive; therefore, it is not usually utilized in rural areas [39]. Electricity is cheap, but it has low coverage in rural areas of most developing countries [40].

2. Literature Review

A solar cooker is a device that uses the sun's energy to cook food [15, 41]. Solar cookers can eliminate the problems that come with utilizing firewood, charcoal, kerosene, and electricity. Unlike firewood, charcoal, and kerosene, solar cookers do not emit harmful gases that can cause air pollution and global warming [31]. Fire accidents will not be a problem in cooking with solar cookers. No trees have to be cut for firewood, which in turn helps to prevent soil erosion [42]. Unlike kerosene, since they use only the sun's energy, they are not expensive. Unlike electricity, they can cover all parts of rural areas without spending a big budget. Box, parabolic, and panel cookers are the three main types of solar cookers [43]. Solar cookers use solar radiation either by reflecting the radiation to concentrate on a cooking pot or by retaining the radiation to trap the heat [44].

A parabolic solar cooker is one of the main solar cookers, which can cook food and boil water at a high temperature within a short period [2, 45, 46]. According to Mbodji and Hajji [47], parabolic solar cookers can be designed and manufactured for thermal applications. In a parabolic solar cooker, the reflecting material, which is shaped in a parabola, receives the sun radiation and reflects it to the bottom of the cooking pot. This causes the heating effect, which will be used to cook different foods [44, 48, 49]. A parabolic solar cooker requires a frequent adjustment of the cooker towards the sun [2].

Arenas experimented on a parabolic solar cooker and discovered that this cooker can achieve an average power scale of 175 W and an efficiency of 26.6% [50]. Al-Soud et al. designed and constructed a two-axis automatic sun tracker parabolic solar cooker and experimented in 2008 for three days. During the experiment, the water temperature had reached 90°C at an ambient temperature of 36°C [46]. Suple and Thombre experimented on a parabolic solar disc that can be operated from the kitchen through biaxial manual tracking [51]. Lee and Rao constructed the three main types of solar cooker and discovered that the parabolic solar cooker achieved the highest temperature at 86.5°C . Moreover, different technologies regarding parabolic solar cookers are being developed throughout the world [52–55].

As far as the knowledge of the authors is concerned, only a few researches have been conducted regarding the performance of parabolic solar cookers in Ethiopia [55, 56]. Moreover, in

Ethiopia, a comparison of the parabolic solar cooker with other fuels in terms of cooking time and energy cost has not yet been investigated. Therefore, this study aimed to design, construct, and evaluate the performance of parabolic solar cookers and compare the cooker with firewood, charcoal, kerosene, and electricity in terms of cooking time and energy cost of cooking.

3. Materials and Methods

3.1. Description of the Study Area. The experiment was conducted in a site, which is located in Addis Ketema subcity, Addis Ababa, Ethiopia. The site is located at $90^{\circ} 02'59''$ and $38^{\circ} 43'54''$ and has an altitude of 2459 m. According to the data that is collected from the Ethiopian metrological agency, Addis Ketema has an average temperature, rainfall, and relative humidity of 15.9°C , 1089 mm, and 60.7%, respectively. Figure 1 shows a map of the study area.

3.2. Experimental Design and Operation of Parabolic Solar Cooker. To construct a parabolic solar cooker, one old satellite dish with its base, four small tyers, steel ($\varnothing = 25$ mm), adhesive, aluminum foil, and a small pot were used. The old dish was first washed with tap water to remove the dirt and dried using a clean towel. Then the surface of the dish was covered with aluminum foil with the help of adhesive. Four small tyers were welded on the stand base so that the cooker can track the sun from east to west. The stand base can also track the sun from north to south because of its capacity to stretch from 72 cm to 108 cm. This particular feature makes the cooker have a dual-axis tracking capacity that can track the sun east to west daily and north to south seasonally. Figure 2 shows the different components of the cooker.

The schematic diagram of the parabolic solar cooker is shown in Figure 3.

The aperture area, receiver area, focal length, rim angle, arc length of the paraboloid, surface area of a paraboloid, length of the circumference, and concentration ratio of the parabolic solar cooker were designed based on the formulas that are listed in Table 1.

By using the calculated focal length, steel support was constructed and welded on the stand base. By considering the diameter of the pot, a receiver, which is used to suspend the pot and keep it on the focal point, was constructed and welded on the support steel. As shown in Figure 4, the bottom part ($\varnothing = 16.00$ cm) of the pot can pass through the ring-shaped receiver ($\varnothing = 16.22$ cm), but the upper part of the pot ($\varnothing = 16.44$ cm) could not pass through the ring.

The pot was painted black because of the high absorption of light and the low reflective property of the color. The depth of the parabola (d) and circumference of the circle (C) were 0.3 m and 5.76 m, respectively. Finally, all components of the cooker were assembled as shown in Figure 5.

3.3. Performance Evaluation of the Cooker. The generated data were analyzed by Microsoft Excel 2013. The performance of the cooker was evaluated using the following formulas:

$$Q \text{ output} = (m1 * Cp * \Delta T) + (L * m2), \quad (1)$$

$$S = \frac{\text{solar radiation data}}{\text{number of data}}, \quad (2)$$

$$Q \text{ input} = (A(\text{m}^2)) * \left(S \left(\frac{\text{kW}}{\text{m}^2} \right) \right), \quad (3)$$

$$\eta = \left(\frac{Q \text{ output}}{Q \text{ input}} \right) * 100\%, \quad (4)$$

$$P = \frac{Q \text{ out (kW)}}{\text{time (h)}}, \quad (5)$$

where η denotes efficiency, Q input denotes heat energy input (kJ), Q output denotes heat energy output (kJ), $m1$ denotes the mass of water before boiling (g), $m2$ denotes the mass of water after water (g), Cp denotes specific heat capacity of water, ΔT denotes a change in temperature, L denotes latent heat of vaporization of water, A denotes aperture area of the paraboloid, S denotes average upcoming solar radiation, P denotes power, and h denotes the hour.

Q output is determined by boiling one liter of water using a parabolic solar cooker for 36 minutes. The Cp and L of water are $4.186 \text{ J/g } ^{\circ}\text{C}$ and 2260 kJ/kg , respectively. The metrological data was used to determine the upcoming solar radiation (S), which in turn helps to determine Q input. The solar radiation data was collected from the Ethiopian metrological stations. Table 2 shows the metrological data of the experimental site during boiling 1 L water. This data was collected from the Ethiopian metrological agency. where A denotes the energy cost of cooking/boiling for a family, B denotes the energy cost of cooking/boiling for a single person, C denotes the consumption of food for one family, which have five members, E denotes the amount of fuel used to cook foods and boil water, and F denotes the cost of fuel in kg for charcoal and firewood, litter for kerosene, and kW for electricity.

$$\begin{aligned} A &= B * C, \\ B &= E * F, \end{aligned} \quad (6)$$

3.4. Quantity of Fuels and Foods Used for Comparison Purpose. Table 3 summarizes the amount of fuels used to cook different foods and boil water so that they could be compared with the constructed parabolic solar cooker in terms of cooking time and energy cost of cooking.

Table 4 summarizes the quantity of foods that are cooked by the parabolic solar cooker and the cooking time interval. In cooking different foods and boiling water, the parabolic solar cooker was adjusted by rotating it from north to south and east to west so that a high amount of solar radiation can be received and reflected to the concentrator. The adjustment was conducted by considering the hour of the day and season. The same type and quantity of foods are cooked using charcoal, firewood, kerosene, and electricity for comparing the parabolic cooker with these fuels. In addition, for this study, the average consumption

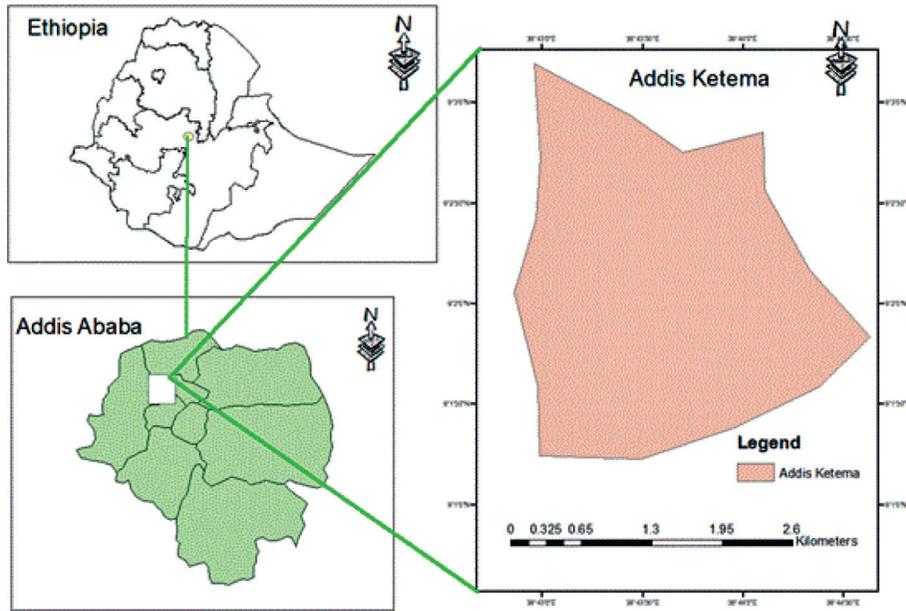


FIGURE 1: Map of the study area.

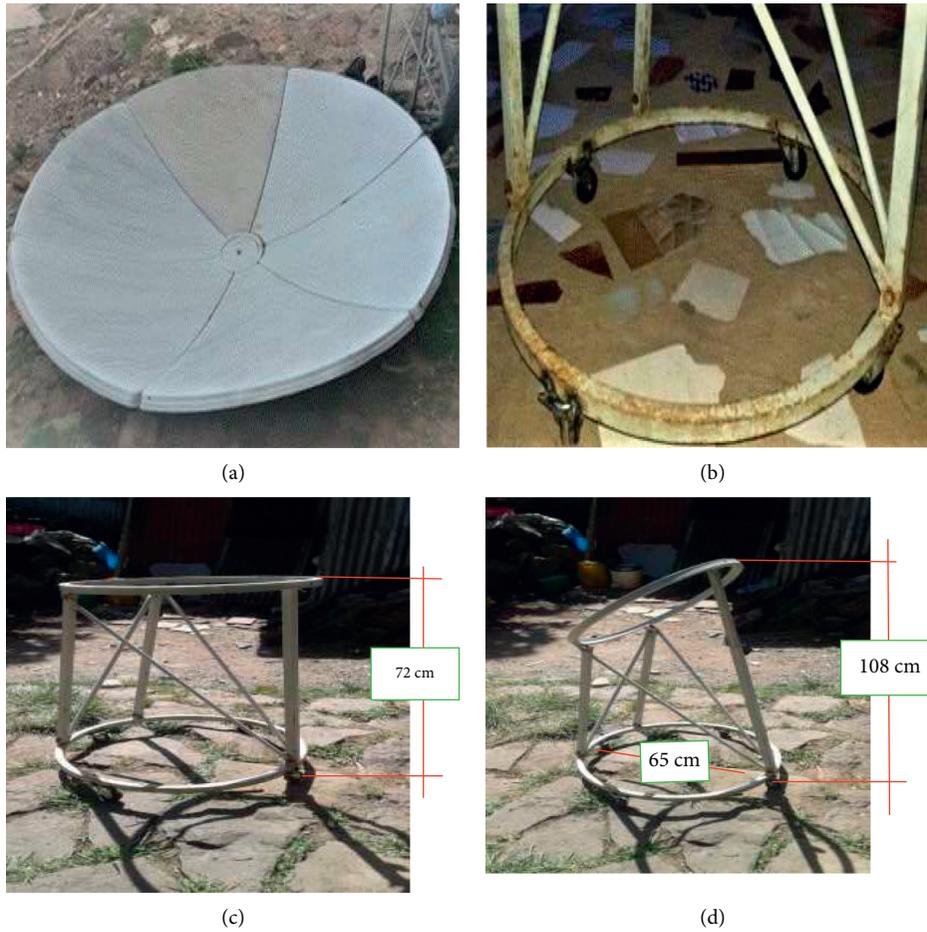


FIGURE 2: Old dish (a), welded tyers (b), and stand base (c, d).

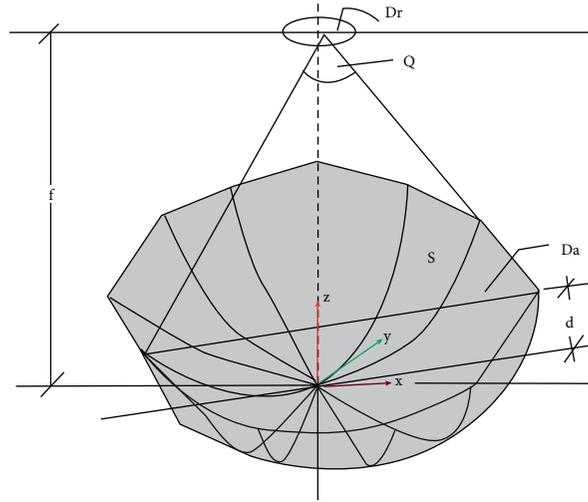


FIGURE 3: Design of parabolic solar cooker, where Da denotes aperture diameter, Dr denotes receiver diameter, S denotes arc length of the paraboloid, F denotes focal length, Q denotes rim angle, and d denotes the vertical length of the curvature.

TABLE 1: Design formulas of parabolic solar cooker.

No.	Parameter	Equations	Equation number
1	Aperture area (Aa)	$\pi (ra)^2$	Equation (1)
2	Receiver area (Ar)	$\pi (rr)^2$	Equation (2)
3	Focal length (F)	$(ra)^2/4h$	Equation (3)
4	Rim angle (Q)	$\tan(Q) = (1/((d/8h) - (2h/d)))$	Equation (4)
5	The surface area of the paraboloid (As)	$(8\pi(f)^2/3) * (((d/4f) + 1)^{3/2} - 1)$	Equation (5)
6	Length of the circumference (L)	$\pi * Da$	Equation (6)
7	Concentration ratio (C)	Aa/Ar	Equation (7)

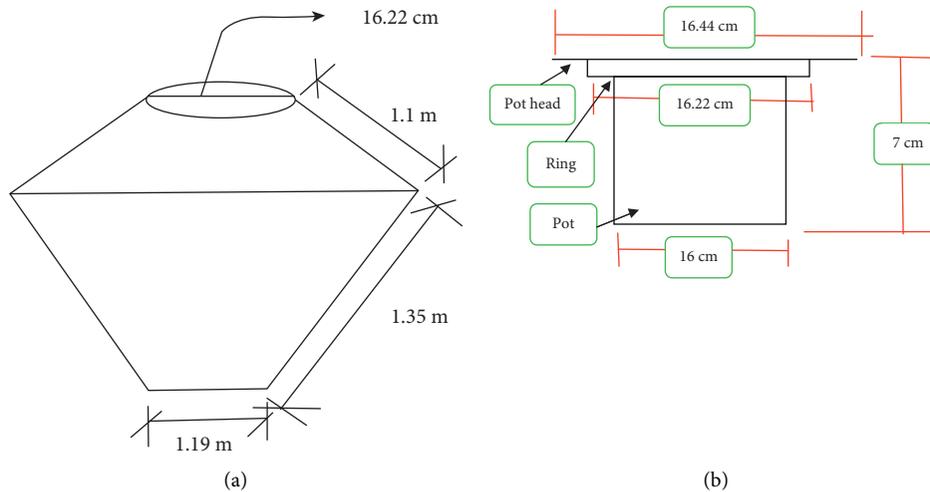


FIGURE 4: The dimension of the steel support (stand) of the cooker (a) and the dimension of the pot with receiver ring (b).

of a family, which has five members, was taken per some specified period.

4. Results and Discussion

4.1. *Design of the Constructed Parabolic Solar Cooker.* Table 5 summarizes the design results of the constructed parabolic solar cooker, which is designed based on the formulas listed in Table 1.

4.2. *Performance of Parabolic Solar Cooker.* The output energy, average solar radiation, input energy, efficiency, and power of the cooker were calculated based on equations (1)–(5) and are presented in Table 6.

The incoming solar radiation was concentrated on the focal point, which is located on the receiver, using the concentrator (parabolic dish). At a time of the day, which has high solar radiation, a high amount of solar radiation will be concentrated on the receiver, which leads to the presence



FIGURE 5: The concentrator of the parabolic solar cooker (a), the cooker with its steel support (stand) (b), and the black-painted pot placed on the receiver (c).

TABLE 2: Metrological data of the experimental site during the experiment (boiling 1 L water).

No.	Date	Time	Wind direction	Wind speed (m/s)	Solar radiation (W/m^2)	Temperature ($^{\circ}C$)
1	April 1, 2020	12:30 p.m.	147.54	7.844	683.2	23.94
2	April 1, 2020	12:45 p.m.	147.52	8.242	706.74	24.06
3	April 1, 2020	1:00 p.m.	109.74	7.128	606.06	24.06
4	April 1, 2020	1:15 p.m.	146.38	7.852	664.6	24.34

TABLE 3: Fuels that were used to be compared with the constructed parabolic solar cooker.

No.	Fuels	Unit price (ETB)
1	Kerosene (L)	20
2	Charcoal (kg)	10
3	Firewood (kg)	20
4	Electricity (kWh)	0.09

ETB: Ethiopian birr.

TABLE 4: Quantity and time interval of foods that are cooked by parabolic solar cooker.

No.	Experiment day	Cooked food	Cooking time interval	Quantity	Consumption of food for one family
1	December 16, 2020	Water	12:00 p.m.–12:12 p.m.	1 L water	15 L/day
2	December 16, 2020	Egg	1:15 p.m.–2:15 p.m.	2 eggs + 1 L water	10 eggs/day
3	December 16, 2020	Potato	2:20 p.m.–4:00 p.m.	2 potatoes + 1 L water	10 potatoes/day
4	December 30, 2020	<i>Nefro</i>	10:45 a.m.–12:25 p.m.	Wheat (150 g) + been (200 g) + 1 L water	4 times/day
5	December 30, 2020	<i>Shero wet</i>	12:37 p.m.–12:55 p.m.	Flour pea (9 soup spoons) + 1 L water	2 times/day
6	March 31, 2021	<i>Siga wet</i>	10:50 a.m.–1:00 p.m.	Meat (0.25 kg) + 1 L water	2 times/day
7	March 31, 2021	Rice	1:52 p.m.–2:35 p.m.	Rice (300 g) + 0.5 L water	1 time/day

TABLE 5: Design parameters of the constructed parabolic solar cooker.

No.	Parameter	Results
1	Aperture diameter (D_a)	1.8 m
2	Aperture area (A_a)	2.54 m^2
3	Receiver diameter (D_r)	0.16 m
4	Receiver area (A_r)	0.02 m^2
5	Depth of the parabola (d)	0.30 m
6	Focal length (f)	0.67 m
7	Rim angle (Q)	67.38 $^{\circ}$
8	Circumference of the circle (C)	5.76 m
9	The surface area of the paraboloid (A_s)	2.81 m^2
10	Length of the circumference (L)	5.76 m
11	Concentration ratio (C)	123.46

TABLE 6: Performance of parabolic solar cooker.

No.	Performance parameters	Result
1	Output energy	0.182 kW
2	Average upcoming solar radiation	0.665 kW/m ²
3	Input energy	1.691 kW
4	Efficiency	10.75%
5	Power	0.3 kW/hr.

of high temperature. The black-painted pot, which is placed on the receiver, will absorb the heat and be used to cook different foods and boil water. In this study, the efficiency of the constructed parabolic solar cooker was 10.75%. However, better efficiency of 37.75% and 26.6% was achieved by [57, 58], respectively.

Many factors could reduce the efficiency of the cooker. Some of the factors are temperature, wind, cloud, day of the year, time of the day, and type of reflective material. Profile deformation, structural torsion, and local irregularities can also affect the efficiency of a parabolic solar cooker [59]. The reflective material that is used in this cooker was aluminum foil. Aluminum foil is a good reflector, but after some time, it will crack. In addition, it will not be placed smoothly on the dish. This causes the rays not to concentrate on a receiver, which in turn reduce the efficiency of the cooker.

4.3. Comparison of Parabolic Solar Cooker with Other Fuels in terms of Cooking Time and Cost. The constructed parabolic solar cooker was compared with charcoal, firewood, kerosene, and electricity in terms of cooking time and cost. Figure 6 shows the cooking time of different foods using the constructed parabolic solar cooker, charcoal, kerosene, firewood, and electricity.

To compare parabolic solar cookers with other fuels, water and different foods are used, whose composition is described in Table 4. In boiling water to 88°C, the parabolic solar cooker took twelve minutes, but charcoal, kerosene, electricity, and firewood took eleven, thirteen, sixteen, and ten minutes, respectively. Except for firewood, a parabolic solar cooker boiled the water faster than the other fuels. In cooking an egg, a parabolic solar cooker took sixty minutes, but charcoal, kerosene, electricity, and firewood took thirty, twenty-nine, twenty-eight, and twenty-six minutes, respectively. Firewood can cook an egg faster than both parabolic solar cookers and the other fuels. In cooking potato, parabolic solar cooker took hundred minutes, but charcoal, kerosene, electricity, and firewood took forty-three, thirteen, fourteen, and fifteen minutes, respectively. Kerosene can cook potatoes faster than both parabolic solar cookers and the other fuels.

In cooking *Nefro*, parabolic solar cooker took forty minutes, but charcoal, kerosene, electricity, and firewood took one hundred thirty-five, ninety, ninety-one, and sixty-three minutes, respectively. The parabolic solar cooker can cook *Nefro* faster than the other fuels. In cooking *Shero wet*, parabolic solar cooker took eighteen minutes, but charcoal, kerosene, electricity, and firewood took seventy-nine, sixty-six, sixty-eight, and sixty minutes, respectively. Except for

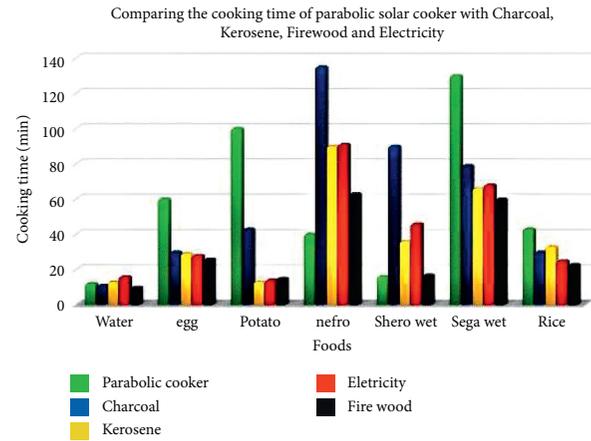


FIGURE 6: Comparison of parabolic solar cooker with other fuels in terms of cooking time.

firewood, a parabolic solar cooker can cook *Shero wet* faster than the other fuels. In cooking *Siga wet*, parabolic solar cooker took one hundred thirty minutes, but charcoal, kerosene, electricity, and firewood took seventy-nine, sixty-six, sixty-eight, and sixty minutes, respectively. Firewood can cook *Siga wet* faster than both parabolic solar cooker and the other fuels. In cooking rice, a parabolic solar cooker took forty-three minutes, but charcoal, kerosene, electricity, and firewood took thirty, thirty-three, twenty-five, and twenty-three minutes, respectively. Firewood can cook potatoes faster than both parabolic solar cookers and the other fuels. Parabolic solar cooker cooks *Nefro* and *Shero wet* faster than any other fuels. The reason for this is the fact that these foods were cooked around noon. It is well known that there is a high amount of solar radiation at noon period. If there is a high amount of solar radiation, the cooking time will be small.

Generally, even though the parabolic solar cooker took a longer time to cook an egg, rice, potato, and *Siga wet* than the other fuels, it cooks *Nefro* faster than the other fuels. It is also the second-fastest cooker in cooking *Shero wet* compared to the other fuels. *Nefro* and *Shero wet* were cooked around solar noon, where the solar intensity becomes highest.

Table 7 shows the energy cost of different fuels to boil one-liter water and to cook one egg, potato, *Nefro*, *Shero wet*, *Siga wet*, and rice. These foods were also cooked by the parabolic solar cooker. The energy cost of these fuels is calculated by considering the amount of fuel used to cook the given foods with a unit cost of the fuel, which is described in Table 3.

As shown in Table 4, a family requires *Shero wet* 2 times per day, *Nefro* 4 times per day, 15 L water, 10 eggs, 10 potatoes, *Siga wet* 2 times per day, and rice 1 time per day. Figure 7 shows the energy cost of different fuels in boiling water and cooking different foods for a single family.

To boil 15 L water/day using charcoal, firewood, kerosene, and electricity, 2.5 ETB/day, 24 ETB/day, 15 ETB/day, and 0.36 ETB/day are required, respectively. To cook 10 eggs/day using charcoal, firewood, kerosene, and electricity, 12.5 ETB/day, 32 ETB/day, 5 ETB/day, and 0.42 ETB/day are required, respectively. To cook 10 potatoes/day using charcoal, firewood, kerosene, and electricity, 12.5 ETB/day, 16 ETB/day, 10 ETB/day, and 0.21 ETB/day are required,

TABLE 7: Amount of fuel used in boiling water and cooking foods for a single person.

No.	Foods	Charcoal		Firewood		Kerosene		Electricity	
		Amount (kg)	Energy cost (ETB)	Amount (kg)	Energy cost (ETB)	Amount (L)	Energy cost (ETB)	Amount (kWh)	Energy cost (ETB)
1	Water	0.025	2.50	0.08	1.6	0.05	1	0.267	0.024
2	Egg	0.025	2.50	0.16	3.2	0.025	0.5	0.467	0.042
3	Potato	0.025	2.50	0.08	1.6	0.05	1	0.234	0.021
4	<i>Nefro</i>	0.075	7.5	0.75	15	0.5	10	1.517	0.137
5	<i>Shero wet</i>	1	10.00	0.5	10	0.4	8	0.767	0.069
6	<i>Siga wet</i>	1	10.00	0.75	15	0.5	10	1.134	0.102
7	Rice	0.025	2.50	0.16	3.2	0.025	0.5	0.417	0.038

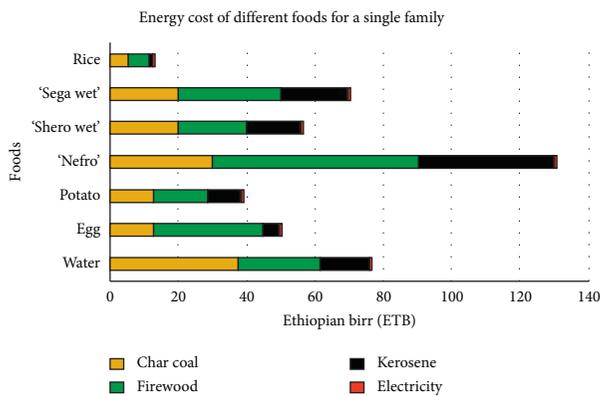


FIGURE 7: Energy cost of different fuels that are used in boiling water and cooking foods for a single family.

respectively. To cook 1 *Nefro*/day using charcoal, firewood, kerosene, and electricity, 30 ETB/day, 60 ETB/day, 40 ETB/day, and 0.55 ETB/day are required, respectively. To cook 2 *Shero wet*/day using charcoal, firewood, kerosene, and electricity, 20 ETB/day, 30 ETB/day, 16 ETB/day, and 0.14 ETB/day are required, respectively. To cook 10 *Siga wet*/day using charcoal, firewood, kerosene, and electricity, 2.5 ETB/day, 30 ETB/day, 20 ETB/day, and 0.20 ETB/day are required, respectively. To cook 1 rice/day using charcoal, firewood, kerosene, and electricity, 5 ETB/day, 6.4 ETB/day, 1 ETB/day, and 0.07 ETB/day are required, respectively. Solar energy is free energy [60]. Therefore, solar cookers in general, parabolic solar cooker, in particular, do not have an energy cost. Therefore, it is preferable technology for developing countries including Ethiopia.

5. Conclusion

A dual-axis sun-tracking solar cooker was designed and constructed using locally available materials. The design parameters were aperture area, receiver area, focal length, rim angle, the surface area of the paraboloid, length of the circumference, and concentration ratio. Its performance was also investigated by calculating its efficiency and comparing it with charcoal, firewood, kerosene, and electricity in terms of cooking time and energy cost of cooking. The average solar radiation reaching the earth's surface on the day of the experiment was 0.665 kW/m^2 . The output energy, input

energy, efficiency, and power of constructed parabolic solar cooker were 0.182 kW, 1.691 kW, 10.75%, and 0.3 kW/hr, respectively. The constructed parabolic solar cooker showed the best performance in cooking *Nefro* and *Shero wet* at a short time compared to the other fuels. The parabolic solar cooker showed a good performance in boiling water for a short time next to firewood and charcoal. However, the parabolic solar cooker took a relatively long time in cooking egg, potato, and *Siga wet*. One of the main reasons for the slow cooking time might be due to the cracking of the reflective material (aluminum foil), which is also responsible for the reduction of the efficiency of the cooker. Since the parabolic solar cooker does not have any energy cost, it can save the energy cost of cooking foods.

6. Recommendation

The reflective material that was used in this experiment was aluminum foil. This material cracks and shrinks after some time, which leads to the reduction of efficiency of the cooker. Therefore, further investigation should be conducted to replace aluminum foil with a reflective material that is strong and durable to improve the efficiency of the cooker. Generally, due to its cost and time effectiveness, a parabolic solar cooker will be a very good technology especially for developing countries including Ethiopia.

Data Availability

All data are available within this article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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