Evaluation of High Density Polyethylene as Alternatives for Wooden Poles in Electric Fence

Tshering Penjor[i], Lhap Dorji[i], Geley Namgay[i], Pema Thinley[i], Choki Nima[i]

ABSTRACT

To reduce wooden pole usage in electric fencing, ARDC-Wengkhar with financial support from the Bhutan Trust Fund for Environment Conservation (BTFEC) has been evaluating High Density Polyethylene (HDPE) pipe as an alternative for wooden poles in electric fence. The trial was conducted in two remote villages in Saling gewog under Mongar dzongkhag. The HDPE with two different specifications of 75mm and 50mm were evaluated. The initial investment cost of HDPE pipe is found to be more than three time higher than that of wooden poles which could not be afforded by average Bhutanese farmers. However, HDPE pole substitution could save about 41.63 m3 of forest volume which could produce Nu. 42,448 worth of ecological services for the country in construction of 1km electric fence.

Keywords: *Crop Damage, HDPE pipe, Electric fence, Ecological Services*

1. Introduction

Crop damages by wild animals continue to be one of the major challenges faced by the farming communities in Bhutan. In the effort to mitigate crop damage, ARDC Wengkharin collaboration with NPPC, Simtokha developed a low cost fabricated electric fence which is currently being promoted nationwide. This has made immense contribution towards resolving human-wildlife conflicts and helped farmers protect almost 80-100% crop loss since 2009. Between 2009 and 2018, a total of 3492 km of electric fences have been established protecting 39, 346 acres of agricultural land across the country (MoAF, 2018).

Although the electric fence has helped ease the crop damage problems, but the need for huge number of wooden poles extracted from government reserved forests is a huge concern expressed by different stakeholders, particularly, the Department of Forests and Park Services. It is estimated that about 450 wooden poles are required to construct 1 km of electric fence (Penjor et al., 2013). Consequently large volume of wood has been extracted from the government reserved forests for construction of electric fences between 2009 and 2018. Additionally, many of these sites could have used more additional wooden poles as replacement due to their short life span. Generally most of the wooden poles used for electric fence in Bhutan need to be replaced within 3-5 years after initial installation although there are hardy species with extended life spans of beyond ten

Corresponding author: tpenjor@moaf.gov.bt
[i] Agriculture Research and Development Center, DoA, Wengkhar, Mongar

years.. Therefore to reduce wooden pole usage in electric fencing, ARDC-Wengkhar with financial support from the Bhutan Trust Fund for Environment Conservation (BTF-EC) has evaluated High Density Polyethylene (HDPE) pipe as an alternative for wooden poles in electric fence. The HDPE pipe has a minimum service life span of 50 years and if it is corrugated it can exceed 100 years (Lester, 1998). The study was conducted in two sites in Mongar dzongkhag with following objectives:

- To compare the initial investment cost of High Density Polyethylene (HDPE) poles with standard wooden poles in establishment of electric fence
- Conduct simple Cost Benefit Analysis of High Density Polyethylene (HDPE) poles within its minimum service life span
- To estimate the value of ecological services provided by the standing trees which are substituted by HDPE pipes

2. Materials and Methods

2.1. HDPE pole specification and manufacturing

The Bhutan Polythene Company Ltd., in Phuntsholing manufactures various types of HDPE pipelines, mainly for drinking water supplies and irrigation purposes. They also manufacture HDPE pipes with customized size and specification based on customer demand. For our study we ordered the following sizes and specification suited for electric fence poles.

- Pipe type= HDPE non-corrugated type
- Pipe outer diameter= 75 mm/50mm
- Pipe length= 2 meter
- Maximum pressure rating =PN 12.5 (187.5 psi)

2.2. Site selection and trial setup

Two villages under Saling geogs, Mongar Dzongkhag were selected to install the electric fence using HDPE poles (Table 1). Another village under Tsamang geog of Mongar Dzongkhag was selected to install electric fence using normal wooden poles (Table 2). Those selected villages are located in remote area and were constantly being raided by wild animals such as wild pig, monkey, porcupines and Samber deer. All the installation procedures and equipment standards were referred from the Technical Reference Manual for Installation and Maintenance of Electric Fence, 2014.

Table 1. Site information on electric fence setup using HDPE poles

Electric fence parameters	Ligar, Thridangbi (50mm HDPE)	Galingkhar (75mm HDPE)
Length of electric fence	430 m	350 m
No. of beneficiary households	3	1
No of HDPE pole used	120 nos	140 nos
Amount of GI wire used	60 kg	50 kg
No of Energizer	1nos	1 nos
Energizer powered by	12V battery, 30 watt solar panel	12V battery, 30 watt solar panel

Table 2. Site information on electric fence setups using wooden poles

Electric fence parameters	Thenbang village under Tsamang Geog, Mongar
Length of electric fence:	1500 m
No. of beneficiary households	5
No of Wooden pole used	675nos
Amount of GI wire used	75 kg
Amount HDPE insulator used	495 m
Amount of 3 inch nail used	63 kg
No of Energizer used	1nos
Energizer powered by	12V battery, 30 watt solar panel

2.3. Cost benefit analysis of high density polyethylene (HDPE) poles

Simple Cost Benefit Analysis (CBA) of HDPE poles were carried out based on Net Present Value (NPV), Benefit Cost Ratio (BCR) and Payback Period (PP) of all the monetary values over the minimum life span period of the HDPE pipe which is taken at 50 years. The discount rate for Net Present Value (NPV) of the cost and benefit were calculated from current interest rate on fixed deposit of the Bank of Bhutan Ltd. which is at 7.25% per annum. The actual length of electric fence installed and amount of material used varied with village but for the study purpose, calculations were made on per kilometer basis. While performing analysis, we assumed the average service life of wooden-poles at 5 years and HDPE pipes at 50 years. The initial costs on purchase of energizer, solar panel, GI wire, batteries, and charge controller are assumed to be same for either type of EF.

2.4. Estimating the value of ecological services provided by the standing trees substituted by HDPE pipes

A study conducted by Kubiszewski et al. (2013) estimated the value of ecological services provided by different forest cover and land use types in Bhutan using benefit transfer methodology. The total value for the ecosystem services in Bhutan was estimated USD 15.5 billion/year (Nu. 760 billion/year) which was significantly greater than the Gross Domestic Product (GDP=USD 3.5 billion/year). Benefit transfer is the process of utilizing existing valuation studies or data to estimate the value of ecosystem services in one location and transfer them to ecosystem services in a similar location (Costanza & Folke, 1997). The transfer method involves obtaining an economic estimate for the value of market and non-market services through the analysis of a single study, or group of studies, that have been previously carried out to value similar services. In the current study, we estimated the value of ecosystem services provided by the volume of forest which were substituted by HDPE pipes by using the baseline data provided by Kubiszewski et al. (2013). The volume of the forest in a hectare is adapted from the findings of DoFPS (2016). The Huber formula ($V=\pi r^2 h$) stated by de Leon & Uranga (2013) has been applied to measure the total volume of forest harvested to construct 1km fence. The total volume of forest harvested to construct 1km fence is computed based on the timber extraction and distribution modalities applied by the Department of Forest and Park Services as 40% timber and 60% firewood on standing volume (DoFPS, 2017).

3. Result and Discussion

3.1. Initial investment cost for establishment

Initial investment (material and installation) cost for HDPE and wooden poles based EF are compared and presented in Figure 1. The figure shows that total investment cost of 75mm HDPE pole is Nu.3, 26,752 which is more than five times higher than the total investment cost of using wooden poles (Nu. 76207) for establishment of 1km electric fence. On other hand, the total investment cost for EF using 50mm HDPE poles is Nu. 1, 72852 which is three times higher than wooden pole based EF. The cost difference is mainly due to the higher cost involved in purchase of HDPE poles from Bhutan Polyethylene Company compared to the minimal cost involved in acquiring wooden poles from nearby forests.

The other cost difference is from the use of 25 mm HDPE pipe and insulator preparation along with that of 3-inch nails in wooden pole based EF. In HDPE pole the fence GI wires are directly passed through the 8 mm diameter holes drilled in the HDPE pole and the additional insulators and 3-inch nails are not required.

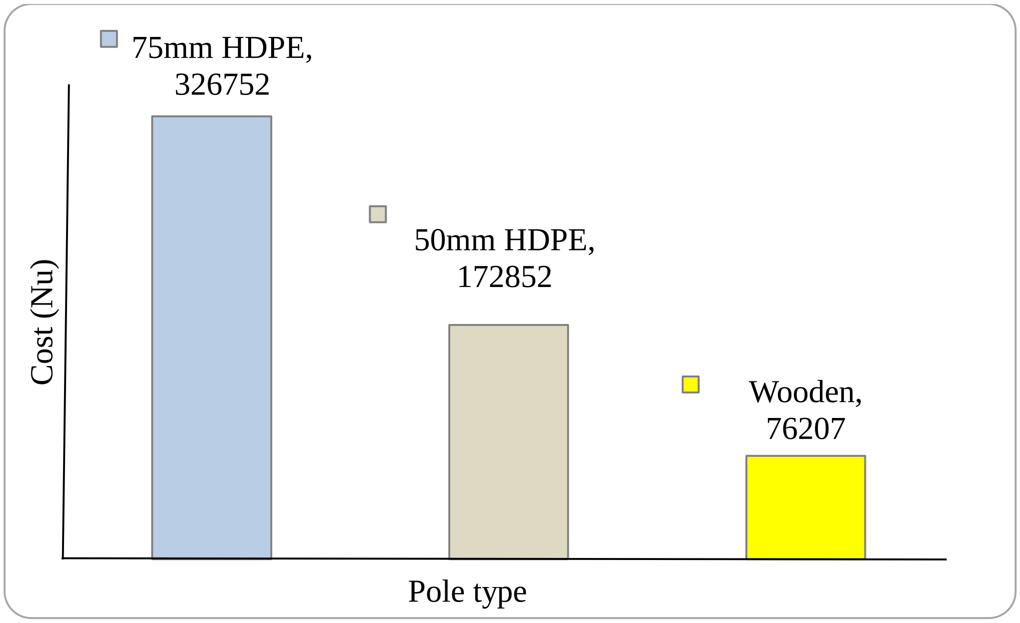

Figure 1. Initial investment cost of three different pole based EF

3.2**.** Cost Benefit Analysis of HDPE pipe as electric fence pole

Simple Cost Benefit Analysis of HDPE poles were carried out based on Net Present Value (NPV), Benefit Cost Ratio and Payback Period of all the monetary values over the minimum life span period of the HDPE pipe and presented. The cost benefit analysis model of 75mm HDPE and 50mm HDPE is shown in the Table 5 and Table 6 respectively. The only difference is the recurrent cost of Nu. 29, 280 entailed for the replacement of wooden poles considering its service life of 5 years. This amount on other hand is assumed as saving or benefit of using HDPE pipe as electric fence pole. This cost includes the cost of wooden poles, transportation and labor charge for reinstallation of electric fence. The CBA model shows that NPV of using 75mm HDPE as EF pole stands at Nu. – 2, 58,985 with the BCR of 0.21 (Table 5).

Table 5. Cost Benefit Analysis of HDPE (75mm) and wooden poles over the period of 50 years for 1km electric fence.

Year	HDPE initial cost	Wooden Pole cost	Benefit of using HDPE	Present Value of benefit (HDPE pipe) at discount rate of 7.25%
0	326752	76207	0	0
5	0	29280	29280	20634
10	0	29280	29280	14541
15	0	29280	29280	10247
20	0	29280	29280	7221
25	0	29280	29280	5089
30	0	29280	29280	3586
35	0	29280	29280	2527
40	0	29280	29280	1781
45	0	29280	29280	1255
50	0	29280	29280	885
Total	326752	369007	292800	67767
			NPV	-258985
			BCR	0.21

The NPV still stands at the negative value of Nu. – 1, 05,085 while running CBA model for 50mm HDPE based EF (Table 6). The BCR of using 50mm HDPE is at 0.39. The result clearly suggests that electric fence establishment using HDPE pipe either of 75mm nor the 50mm specification is not financially feasible at the present interest/discount rates.

Table 6.Cost Benefit Analysis of HDPE (50mm) and wooden poles over the period of 50 years for 1km electric fence.

Year	HDPE initial cost	Wooden Pole cost	Benefit of using HDPE	PV benefit HDPE
0	172852	76207	0	0
5	0	29280	29280	20634
10	0	29280	29280	14541
15	0	29280	29280	10247
20	0	29280	29280	7221
25	0	29280	29280	5089
30	0	29280	29280	3586
35	0	29280	29280	2527
40	0	29280	29280	1781
45	0	29280	29280	1255
50	0	29280	29280	885
Total	172852	369007	292800	67767
			NPV	-105085
			BCR	0.39

The small discounted benefit accumulated at the end of HDPE service life of 50 years is worked to figure out the period where by the cumulative cost equals to cumulative return of the technology (figure 2). The cumulative return of using HDPE at the end of its service life accounts to Nu. 67, 767 which is far less than the initial establishment cost of Nu. 1, 72,852.

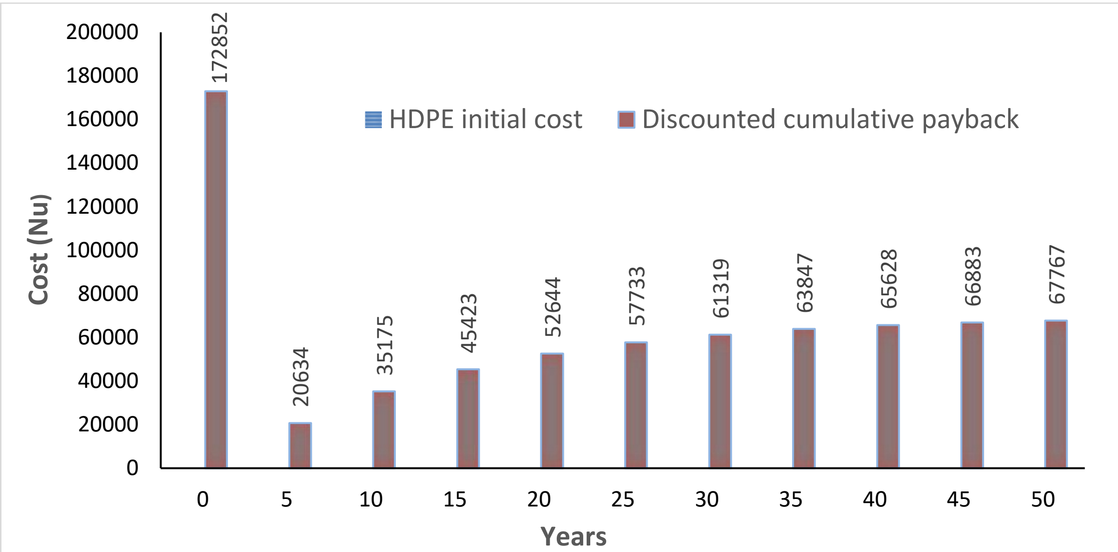

Figure 2. Payback time of HDPE pipe (50mm) within its service period of 50 years

3.3. Estimating the value of Ecological Services provided by the standing trees substituted by HDPE pipes

Forest ecosystem provides different types of services which are generally divided into economic value, ecological value and social value. The ecological value mainly includes the water conservation, soil conservation and fertility, soil improvement, carbon sequestration and oxygen release, environment purification, forest protection, biodiversity maintenance and so on (Krieger, 2001). The value of ecological services in Bhutan was first estimated by Kubiszewski et al. (2013) at a mean value of US $ 5040 per hectare/year by the temperate forests. This value was used in our study to estimate the value of ecological services that may be produced by the number of standing trees which are substituted by HDPE pipes, and otherwise would be cut down and used in electric fence.

In Bhutan, the volume of forest is estimated at 346 m^3 per hectare (DoFPS, 2016). A total volume of 41.63 m^3 of forest is harvested in constructing 1 km fence. Therefore, our analysis assumed that every 1 km length of electric fence would save 41.63 m^3 of forest having wooden fence pole replaced by HDPE. As presented in Table 7, total value of ecological benefit of US $ 606.40 is banked in very first year while using HDPE as alternative to wooden poles in construction of a 1 km fence. Through the entire service life of HDPE, the ecological value reaches to Nu. 4, 66,928 computed against wooden poles being replaced at every 5 years interval. Based on this assumption, a total forest volume of 457.93 m^3 will be saved at the end of 50 years by constructing and maintenance a 1 km HDPE fence.

Table 7. Value of Ecological Services provided by the standing trees

Year	Vol. of forest harvested to construct 1km fence (m3)	Total vol. per hectare by forest (m3)	Ecological service value per year/hectare ($)	Total value of ecological service ($)
1	41.63	346	5040	606.4
50	457.93	346	5040	6670.4
	Total value in Nu.			466928

4. Current attribute of Electric Fencing to forest ecological service

A total length of 3492 km of electric fencing (EF) was constructed within the span of 9 years (2009-2018) in our country accounting to 15,71,400 numbers of wooden poles. This translate to 1, 45,371.96 m^3 of forest harvest exclusively for construction of EF. Subsequently 420 hectares of forest has been already harvested within these 9 years in addressing human wildlife conflict. By now, Bhutan has lost the ecological value worth of Nu. 2.1 million, which otherwise should have contributed by that volume of forest used in constructing EF. The officials with Department of Forest & Park Services stated that on an average there is a demand of 10,000-12, 000 numbers of fencing posts from one chiwog annually. If applied to gewog, dzongkhags and the country as a whole, it translates to huge destruction to forest within short period. Further, this will affect the growth of non-wood forest products as well as eventually lead to wild animals interfering with the human settlements.

5. Conclusion

Electric fence has hugely helped Bhutanese farmers in protecting their crops from wild animals' damage. However, the need for huge number of wooden poles to install electric fence from government reserved forests is a major concern in terms of sustainability. ADRC- Wengkhar conducted the study on the use of High Density Polyethylene (HDPE) pipe as an alternative to wooden poles in electric fence in 3 villages in the eastern Bhutan. The initial investment cost of HDPE pipe is found to be than three time higher than that of wooden poles which in no way could be paid back from the accumulated benefits within the service life of the HDPE pipes. We also estimated the monetary value of the ecological services of the forest which are substituted by HDPE pipes. The ecological service provided by these forests within the service period of the HDPE pipes is estimated to be worth at Nu. 0.47 Million in construction of 1km EF. This benefit will motivate those in the government or decision-makers to opt for HDPE-based electric fence system. The initial investment cost should be subsidized or borne by the government or else most Bhutanese farmers will not be in a position to reap the benefit HDPE-based electric fence.

Acknowledgement

We thank the Director and his officials in Bhutan Trust Fund for Environment Conservation (BTFEC) for the financial support for carrying out this project

References

Chhetri, P. B., Penjor, T., Nima, C., & Yangzom, D. (2013). Impact assessment on selected socio-economic indicators of farming communities after fencing their agricultural farms using locally fabricated electrical fence in eastern Bhutan. *Journal of Renewable Natural Resources Bhutan, 9*, 129-140.

Costanza, R., & Folke, C. (1997). Valuing ecosystem services with efficiency, fairness and sustainability as goals. In G. C. Daily (Ed.), *Nature's Services: Societal dependence on natural ecosystems* (pp. 49-70). Washington D.C.: Island Press.

de León, G. C., & Uranga-Valencia, L. P. (2013). Theoretical evaluation of Huber and Smalian methods applied to tree stem classical geometries. *Bosque, 34*(3), 311-317.

DoFPS. (2017). *National Forestry Inventory: Stocktaking nations forest resources*. Thimphu: Department of Forest and Park Services (DoFPS), Ministry of Agriculture and Forest. Bhutan.

DoFPS. (2017). *Timber Extraction and Distribution Modalities*. Thimphu: Department of Forest and Park Services (DoFPS), Ministry of Agriculture and Forest. Bhutan.

Krieger, D. J. (2001). *Economic value of forest ecosystem services: a review*. Washington: The Wilderness Society

Kubiszewski, I., Costanza, R., Dorji, L., Thoennes, P., & Tshering, K. (2013). An initial estimate of the value of ecosystem services in Bhutan. *Ecosystem Services, 3*, e11-e21.

Lester, H. G. (1998). Service Life of Drainage Pipe. *Synthesis of Highway Practice* (254).

Ministry of Agriculture and Forest. (2018). *11th FYP Terminal Review Report*. Thimphu: Ministry of Agriculture and Forest.

Penjor, T., Dorji, L., Nima, C., Yangzom, D., Chhetri, P. B., Norbu, T. (2013). *Technical Manual on Installation and Maintenance of Electric Fence*. Mongar: Agricuture Research and Development Center- Wengkhar, Department of Agriculture, Ministry of Agriculture and Forest.