A STUDY ON THE EVALUATION OF DEMINING PROJECT FOR THE INFRASTRUCTURE REHABILITATION BASED ON BENEFIT COST ANALYSIS[*]

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1. Introduction

(1) Research background

Landmine is an explosive material, which hinders economic development long after the end of the conflict. To be able to rehabilitate the economy, such as to rehabilitate the infrastructure, first, landmine must be removed. Because of the budget constraint, which mine normally encounter affected countries; careful project evaluation must be conducted so that the project is cost efficiently run in the long term. This paper will look into the Benefit-Cost analysis for the demining project that is a tool to support the infrastructure rehabilitation in mine affected area.

(2) Research Review

There are four basic methods being used in mine/UXO clearance at the present day: sniffing (mine detection dog), metal detection, prodding (by manual) and mechanical. The methods and the technology used at the present day are so primitive and little has changed since their creation about a hundred years ago. In comparison to the mine deployment technique - from manual deployment to the deployment from the air- the demining project is a long-time business. To solve the gap between mine deployment technology and mine clearance, many researches have been done. Many of them are concentrated on developing the tools and technology to detect, clear and destroy landmine at much better performance. Those active researches are partly encouraged by the high demand from national defense section that required the manufactured to keep abreast new machine and technology that could assist the national defense interest during time of hostility.

In poor country where the landmine exists, having a better tool to use is not the only factors to enjoy clearing landmine. Because of their resource is usually short, the question of which area to be cleared so that the project could generate maximum benefit to the user in the long term is one of the most important questions.

(3) Research objective

The objective of this study is to assist the infrastructure development in mine affected country by identifying the benefit and cost of the demining project. Simply speaking, this paper would answer the question of how much benefit and cost in monetary term to clear the particular minefield so that this result could be used for infrastructure rehabilitation in mine affected country.

(4) Research methodology

Because of this paper attempt to conduct the research of demining to assist infrastructure rehabilitation, most of the parameters are related to the demining in infrastructure area. There are two main sections in this research, each contribute to the identification of variables and parameter that could be used to conduct Benefit and Cost analysis. In Benefit analysis, however, the benefit is obtained from direct and indirect benefit of the demining project. The direct benefit is value that save human life, livestock and vehicle from being killed or destroyed by landmine. The indirect impact, on the other hand, is the benefit from economic growth generated by the infrastructure development after the completion of the development project.

In the direct impact however, only the parameters to identify the benefit to safe human from being killed or injured are studied. This is purely because of the limitation of data available. Therefore, once the data available this procedure could be used to identify the remaining parameters. The model to be used for the identifying of the value of Benefit and Cost is Multiple Linear Regression (MLR) model, which is a powerful tool to predict Benefit and Cost value with different variables. More to say, MLR enable us to understand how Benefit and Cost change when the variables is not constant.

2. A description of Benefit-Cost Analysis Model

Benefit-Cost analysis compares alternative demining projects considering their effects expressed in monetary terms. In this study the Net Present Value is used. The Net Present Value method calculates the cash flows over the life of the project (period of T years) and discounts them to today's dollar terms. Future cash flows are discounted due to the fact that money has a time value.

[*] Keywords: Benefit-Cost, Landmine, Unexploded Ordnance (UXO)
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$$P_i^{NPV}(r) = \sum_{t=1}^{T} \frac{(B_i^t - C_i^t)}{(1+r)^T} \quad \text{...(1)}$$

Where,

P_i^{NPV}	Present Value of project i (\$)	;	C_i^t	Cost of project i at time t (\$)
B_i^t	Benefit of project i at time t (\$)	;	r	Discount rate

(1) Benefit value

The benefit value of the demining project is the value that is generated by the prevention from the loss of human life, animal and property to the explosion. In addition to that this benefit could be obtained from the indirect benefit which is the benefit of the economic growth once the infrastructure rehabilitation is completed. Therefore, benefit equation could be written as:

$$B_i = N_{dead(i)} * \theta + N_{inj(i)} * \psi + LS_j * \varpi_j + PR_k * \lambda_k + \phi \quad \text{............(2)}$$

Where,

$N_{dead(i)}^t$	Is a number of mine/UXO victim (dead) that will occur at project i at year t (person)
$N_{inj(i)}^t$	Is a number of mine/UXO victim (injured) that will occur at project i at year t (person)
LS_j	Is a number of life livestock loss due to landmine/UXO explosion (animal)
PR_k	Is a number of vehicle loss due to landmine/UXO explosion (unit)
θ	Is a welfare value lost for dead victim from mine/UXO accident at time t (\$/person)
ψ	Is a welfare value lost for injured victim from mine/UXO accident at time t (\$/person)
ϖ_j	Is a unit cost for life stock where as j is kind of life stock
λ_k	Is a unit cost of property where as k is a type of property
ϕ	Is the value of economic growth which is generated by demining project

To be able to identify the number of dead and injured by mine/UXO at minefield i, first the number of dead/injured density within the country of that particular year must be obtain. Then it is assumed that this dead/injured density would apply to minefield i as well. Therefore, the number of dead and injured victims at project i is:

$$N_{dead(i)}^t = \frac{TNV^t}{TMFS^t} * \xi * s_i \quad ; \; N_{inj(i)}^t = \frac{TNV^t}{TMFS^t} * \tau * s_i \quad \text{...(3)}$$

Where,

TNV^t	Is a country's total number victim (dead & injured) from mine/UXO accident (person)
$TMFS^t$	Is a total minefield size in the country at time t (m^2)
ξ	Is a dead ratio of mine/UXO victim (according to HI report in 1998-1999 $\xi = 0.2$)
τ	Is a injured ratio of mine/UXO victim (according to HI report in 1998-1999 $\tau = 0.8$)
s_i	is a minefield size that would be cleared by project i (m^2)

(2) Cost value

There are seven variables that directly affect the demining cost:

- Distance to minefield: is the distance from the demining camp to the minefield (km).
- Land use type: There are four land use types which have been used by the demining agencies: housing, agriculture, development and infrastructure. For this study, dummy variable is used. The dummy variable for infrastructure is 1 and non-infrastructure value is 0.
- Season: this Variable affects directly to the value of unit cost for the fact that it give constraint for mine/UXO clearance. In dry season, the land is becoming harder made mine prodding more difficult and time consuming, however, in wet season land is softer but the work is occasionally interrupted by the weather. In this study when the minefield clearance starts in dry season (January – May), its value is 1 and when it starts in wet season, its dummy variable is 0.
- Density of landmine: is the number of mine per hectare.
- UXO density. is the number of UXO per hectare.
- Density of fragment per hectare. Fragment is a piece of metal that exist in the minefield. During mine detection, this fragment gives a false alarm. Due to the detecting machine at the present day could not differentiate between real mine and fragment, therefore, all fragment must be removed. More fragment remain in minefield, the longer time it take to detect and to remove it (piece/ha)

- Density of population who are living in the minefield before the clearance (person/ha).

Therefore, cost could be written as:

$$C_i = \alpha_0 + \sum_{j=1}^{7} \beta_j^i * x_j \quad \text{...(4)}$$

Where,

C_i : Is a Demining cost ($/ha) , β_j^i : is parameters , α_0 : is an indirect cost , x_j Is Variables

<u>3. The Analysis of the Benefit of Demining Project</u>

a) The Welfare value of the dead and injured person

For human, the welfare value for death and disablement is estimated by the lost of victim's potential productivity or his potential contribution to the Gross National Product. Victim's productive potential is considered equal regardless of sex, type of an employment and victim's age. The productive age to be used in this study is estimated around 40 years. Assuming that each person contributes about $300 per year to Gross National Product (GNP), therefore, $12,000 of welfare value would be loss to one landmine victim. For a developed country, this figure might be much higher. A disable landmine victim, however, the cost is higher. This is because the patients lack the ability to contribute to GNP and in addition to that he required extra medication, hospitalization and recovery. It is estimated that about $3,000 would be required to cover the cost for landmine injured victim.

c) The Number of dead and injured by mine/UXO accidence (N^t)

According to statistics of mine/UXO victims obtained from Handicap International (HI) and Cambodian Mine Action Center (CMAC), there were 3036 accidents. With the combination of many factors such as the improvement of national security, continue mine/UXO clearance, mine awareness program, the number of victim continue to fall to 567 in year 2002 (statistics in September). From this statistics and from the regression analysis we could project the mine/UXO victims at year t :

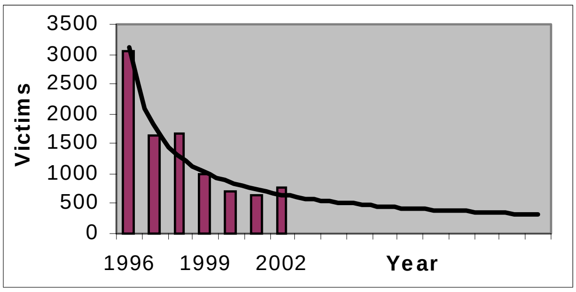

Fig. 1: The decline of Mine/UXO victims in Cambodia

Table 1: Mine/UXO victim statistic in Cambodia

Year (t)	Total Number of Victims (TNV) per year
1996	3036
1997	1644
1998	1685
1999	1005
2000	720
2001	646
2002	567 (Sept. data)

Source: HI, CMAC, 2003

$$TNV^t = 3104.4 * (t - 1995)^{-0.8024} \quad \text{.................................(5)}$$

d) Total size of minefield at time t ($TMFS^t$)

Minefield in Cambodia had been previously estimated around 3,000 km^2. However, it was until the completion of National Survey Level One in early 2002 that additional 1,000 km^2 had been found. Therefore, this study would use total minefield size $TMFS^{2002} = 4{,}000\ km^2$. This size would be reduce annually (over the n years) at the rate of 40 km per year or $r = 1\%$.

$$TMFS^t = 4 * 10^9 * (1 - r * n) \quad \text{......................................(6)}$$

Replace (2) by (3), (5) and (6), we got,

$$B_i^t = \frac{3104.4 * (t - 1995)^{-0.8024}}{4 * 10^9 * (1 - r * n)} * s_i * (0.2 * \theta + 0.8 * \psi) \quad \text{.........................(7)}$$

<u>4. The Analysis of Cost of the Demining Project</u>

a) The characteristics of data

A data that would be used in this analysis is obtained from the Cambodian Mine Action Center and UN-USA funded Adopt-A-Minefield Program. The data describes about the clearance information of 21 minefields, which are all located near the Cambodian-Thai border and had already been cleared between 1999 and 2001. Because of the multiple count of area clear during mine/UXO clearance operation (for safety precaution the clearance of minefield buffer zone is also counted at field level), this study would only use the minefield size, which is produced by the CMAC's database section (eliminate multiple counting). The average size of those minefield are around three hectares, their clearance rate cost ranges between ten thousand dollars to twenty thousands dollars per hectares. This clearance cost does not represent the actual clearance cost. This cost is the subsidy cost given by the donors. In the field where the demining is taking place, the definition of land use type is not clearly defined particularly between housing (resettlement), development and infrastructure. This is because of those three are closely related to each. For instance, demining a plot of land for x displaced families for housing, but the project does not only clear the housing plot but also demine the road that connects the villagers to the nearby community. The same phenomenon has been found in the demining of development type. Another constraint of demining is to identify the beneficiary, some of whom already lived in the minefield. To obtain the accurate figure of those living in the minefield is difficult and dangerous since the area is not accessible before clearance.

b) The analysis of variables' Correlation and parameters

Because of the result obtained from Multi Linear Regression model, we found that distance to minefield and season has the highest correlation to the cost of demining per hectare. In contrast, mine density, UXO density and fragments density per hectare, are having little correlation. The negative value of correction also found to three variables: season, density of UXO and the density of people living in the minefield before clearance. This could be explained that demining during dry season is cheaper than demining in wet season (dummy variable for dry season is 1) by $68.64/ha (however, this estimation is not close to the accurate due to its T value is too small: -0.04). But this finding might be true for the reason that even the rain during wet season soften the soil which enable prodding more easy for manual demining but the demining might be interrupted by this weather as well.

Table 2: Linear regression analysis output for demining cost

	B value	T Value
(Constant)	1234.46	0.42
Distance to minefield, (km)	1613.43	4.31
Land use (infrastructure and non-infrastructure)	-2938.60	-1.68
Season (dry and wet season)	-68.64	-0.04
Mine density (piece/ha)	-25.45	-1.31
Unexploded Ordnance density (piece/ha)	193.38	1.27
Fragment Density (piece/ha)	-0.03	-1.02
Population density in Minefield (person/ha)	-107.73	-1.71
Coefficient of Determination (R square)	0.636	

Similarly, base on the Multi Linear Regression result we also found that any minefield that does not have people to reside within the perimeter, that minefield is cheaper to clear than the one that has a refugees or internal displace person living inside. The clearance cost per hectare without residents inside is lower by $107.73 per person per hectare. From professional demining background, this finding is realistic in term of the correlation between cost and in-minefield residents. In practice, demining land which is partly occupied by local is sometime time and cost consuming such involving with compensation to the lost of their vegetation and productive hours.

More interestingly, the Unexploded Ordnance density which has a positive correlation with the cost of demining land, obtain negative parameter value after computing with other parameters in order to produce the final clearance cost. This could not be explained to the fact that the higher the density of fragment the more time it will be lost to detect and remove this metallic piece. Usually the speed of the demining is closely related to this issue. If the land does not have much metallic contamination (fragment), the demining progress is high, which implies that demining cost is low. The statistics also reveal that the estimation by Multi Linear Regression analysis is quite reliable due to its T value is -1.02. Likewise, parameter and its T value for landmine density is negative after computing with other variable to identify final clearance cost.

5. Conclusion

To sum up, Benefit value in demining project which has been carried out by this paper is mainly the welfare value to compensate to the lost of productivity which would have been generated by the landmine victim. Demining cost per hectare, on the other hand, is related to seven variables. In the evaluation process, if the benefit value exceeds the cost value, meaning that if the net benefit value is positive it is indicated that the project is feasible to be implemented. For the long term project implementation, the comparison of cost and benefit against interest rate is important to find out the Net Present Value. However, there are many other factors both internal and external of demining issue that influences the Value of Benefit and Cost.

References

1) Handicap International (2000): Mine/UXO casualties and Casualty Surveillance in Cambodia
2) Paul Davies– Nic Dunlop, (1994): War of the Mines, 144 pages
3) Cambodian Mine Action Center, (2001): CMAC Integrated Work Plan 2001
4) Cambodian Mine Action Center, (2002): CMAC Five-Year Strategic Plan (2003-2007)
5) Rae McGrath, (2000): Landmines and Unexploded Ordnance (a resource book)
6) VVAF, (2001): After the Guns Fall Silent- The Enduring Legacy of Landmines