CHAPTER 4

EVALUATION OF THE APPROACH

Some hypothetical data are used in this chapter to test this methodological approach of sustainability of onchocerciasis control program in Benin. The evaluation of the approach to this study is comprised of three sections:

- onchocerciasis demand function,
- willingness and ability to pay
- community involvement

The three sections combined together will help us to explain in which condition the program can be sustained. What could happen in the future if the program can not be sustained. The analyses are structured as follows:

Estimated coefficients and descriptive statistics
Policy simulations

4.1 Onchocerciasis control demand function

Assuming one district in endemic onchocerciasis areas in the north region of Benin, where ivermectin treatment is indicated. Three communes are selected in this district with 400 households (200 households with low income and 200 households with middle and high income). We select the household according to the socio-economic survey did by CREDESA 1989. A household, which earning is below F CFA 50,000 is assumed low -income group.

4.1.1 Analysis of the multiple regression equation

By using Ordinary Least Squares method of estimation, and classified into two groups, we obtain the result below

Low income group

Table: 11 Low-income group parameters

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y_{pi}/P_{mi}	0.157668	0.004364	36.12991*	0.0000
C	-0569872	0.177550	-3.209634 *	0.0014
R-squared	0.916346			
Adjusted R-squared	0.905758			
Log likelihood	-0.557288			
Durbin-Watson Stat.	1.2684			
F-statistic	1.305.370			
Prob(F-statistic)	0.0001			

Remark: * indicates significant at 0.05 level.

The model of regression is:

$m_{pi} = 0.15\ y_{pi}/p_{pmi} - 0.56$ (20)

Where:
m_{pi} is the number of people the head of "poor household" is able and wants to treat
Y_{pi} = "poor household" earning
P_{pmi} = price of treatment

The independent variable is significant at 5% level of significance. The coefficient of multiple determination R^2 is 0.916346 and the adjusted R^2 is 0.905758. It means that 90% of the number of people a household is able and wants to treat can be explained by the independent quantitative variables. Prob (F-statistic) = 0.0001. The regression coefficient is positive, indicates that when the income increases or the price of treatment decreases the number of people the household wants to treat increase (assumption, ceteris paribus).

Middle and high income group

Table: 12 Rich group parameters

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y_{ri}/P_{mi}	0.077121	0.002399	32.20958*	0.0000
C	1.034041	0.296518	3.487275*	0.0005
R-squared	0.922736			
Adjusted R-squared	0.912040			
Log likelihood	-870.5255			
Durbin-Watson Stat.	1.2684			
F-statistic	1.1153			
Prob(F-statistic)	0.0000			

NB: * indicates significant at 0.05 level

The demand function for a rich household is as follows:

$m_{ri} = 0.077\ y_{ri}/p_{mi} + 1.03$ (21)

Where:
- m_{ri} is the number the "rich household" is able and wants to treat

Y_{ri} = "rich household" earning
P_{mi} = price of treatment

The independent variable is significant at 5% level of significance. The coefficient of multiple determination R^2 is 0.922736 and the adjusted R^2 is 0.912040. It means that 91% of the number of people a "rich household" is able and wants to treat can be explained by the independent quantitative variables.

Prob (F-statistic) = 0.0000. The regression coefficient is positive, it means when the income increases or the price of treatment decreases the number of people the household wants to treat increases (assumption, ceteris paribus).

Price elasticity of demand

Changes in the price of onchocerciasis control will lead to changes in the quantity of demand h; and the elasticity of demand is intended to measure this response. This elasticity, then records how quantity changes (in percentage terms) in response to a percentage change in P_m.

For rich

The demand function is

$$m_{ri} = 0.077\, y_{ri}/p_{mi} + 1.03 \qquad (21)$$

Assume that ε_r is the elasticity for the rich people; then

$$\varepsilon_r = \frac{\partial m}{\partial P_m} * \frac{p_m}{m} \qquad (22)$$

From (21)

$$\frac{\partial m}{\partial P_m} = -\,0.077\, Y/P_m^2 \qquad (23)$$

substitute (23) into (22) then we have

$$\varepsilon_r = -0.077\, \frac{Y}{P_m^2} * \frac{p_m}{m}$$

$$\varepsilon_r = -\,0.077\, \frac{Y}{P_m . m} \qquad (24)$$

According to the high income group, the average income Y_r^0 is 112 660 F CFA, the average price of treatment P_m^0 is 998 F CFA and the average quantity of demand m_r^0 is 9.94

Assume $Y = Y_r^0$

$P = P_h^0$

$m = m_r^0$

then $\varepsilon_r = (-0.077 \times 112660)/ (998 \times 9.94) = - 0.8$

$\varepsilon_r = - 0.8$ means that a percent rise in price leads to a 0.8 percent decline in quantity (number of people treated).

Table13 shows us the terminology for a demand curve to distinguish value of ε.

Table: 13 Terminology for a demand curve to distinguish value of ε.

Value of ε at a point	Terminology of curve at this point
$\varepsilon < -1$	Elastic
$\varepsilon = -1$	Unit elastic
$\varepsilon > -1$	Inelastic

$\varepsilon_r = - 0.8 > - 1$ means onchocerciasis prevention demanded is undoubtedly inelastic for the rich. The quantity demanded is not response to price. It implies for the rich, they consider that onchocerciasis control is very necessary for them.

For low income group

The demand function is

$$m_{pi} = 0.15\, y_{pi} / p_{pmi} - 0.56 \qquad (20)$$

Assume that ε_p is the elasticity for the poor people; then

$$\varepsilon_p = \frac{\partial m}{\partial P_{pm}} * \frac{p_{pm}}{m} \qquad (25)$$

From (20) $$\frac{\partial m}{\partial P_{pm}} = - 0.15\, Y/ P_{pm}^2 \qquad (26)$$

substitute (22) into (21) then we have

$$\varepsilon_p = - 0.15 \frac{Y}{P_{pm}^2} * \frac{p_{pm}}{m}$$

$$\varepsilon_p = - 0.15 \frac{Y}{P_{pm}.m} \qquad (27)$$

According to the low income group, the average income Y_p^0 is 37 134.8 F CFA, the average price of treatment P_{pm}^0 is 996 F CFA and the average quantity of demand m_p^0 is 5.44

Assume $Y = Y_p^0$
$P = P_{ph}^0$
$m = m_p^0$

then $\varepsilon_p = (-0.15 \times 37134.8)/(996 \times 5.44) = -1.02$

$\varepsilon_p = -1.02$ means 1 percent rise in price leads to 1.02 percent decline in the quantity (number of person treated).

$\varepsilon_p = -1.02 < -1$ means a curve is elastic, price affects quantity a lot. Therefore for the poor the price of the treatment has an impact on them. On the other hand, the rise in price will have a great effect on the number of people treated among the low-income group; (income effect).

Table 14 shows the response of change in the price of treatment for both group, rich and poor.

Table 14: response of change in price of treatment

Rise in price (%)	Decrease in number of people treated (%)	
	Rich	Poor
10	8	10.2
20	16	20.4
30	24	30.6
50	40	51

When the price increases by 10 % the rich and poor decrease the number of people treated respectively by 8 % and 10.2 %. And 30 % rise in price leads to 30.6 % decrease in number of people treated for the poor, and 24 % for the rich.

ONCHOSIM simulations (WHO/TDR, 1997) have indicated that, on the basis of ivermectin being predominantly a microfilaricide with some macrofilaricide activity (quantified at around 30%), it would take up to 50 years with annual ivermectin treatment alone at a coverage rate of 65% of the total population to achieve eradication. Many others studies show that in riverine communities with a high intensely of onchocercal transmission and infection; at least 70% of each household or the total population should be treated for many years to achieve eradication.
This result reveals that if the price of treatment increase by 30 % rich and poor will reduce respectively 24 % and 30.6 % the number of people treated in their community. Therefore the most gratifying achievement which is 9 millions children who have been

spared the risk of onchocercal blindness, 30 millions people who are protected from infection by the disease, 1.5 million Who have lost their onchocercal infection; will face again onchcerciasis manifestations.

Utility calculation

High income group

Let $V_r (P_{rm}, P_x, Y_r)$ is the indirect utility for the rich people. From equation (11) we have:

$$\ln V_r (P_{rm}, P_x, Y_r) = \ln Y_r - 0.077 \ln P_{rm} - (1 - 0.077) \ln P_x . \qquad (28)$$

Where Y_r = income, P_{rm} = price of treatment and P_x = price of others goods

Assuming that

$Y_r = Y_r^{\,0}$, where $Y_r^{\,0}$ is average income of the rich
$P_{rm} = P_{rm}^{\,0}$, where $P_{rm}^{\,0}$ average price of treatment for the rich.
Let P_x represented by consumer price index in 1997 in Benin.

$Y_r^{\,0}$ = 112,660 F CFA
$P_{rm}^{\,0}$ = 998 F CFA
P_x = 180.44

$$\begin{aligned} \text{Then } \ln V_r (P_{rm}, P_x, Y_r) &= \ln (112,660) - 0.077 \ln (998) - (1- 0.077) \ln (180.44) \\ &= 11.63 - 0.53 - 4.79 \\ &= 6.3 \end{aligned}$$

$$V_r (P_{rm}, P_x, Y_r) = e^{6.3} = 544.5$$

Low income group

Consider $V_p (P_{pm}, P_x, Y_p)$ the indirect utility for the poor people. From equation (11) and according to their demand function we have:

$$\ln V_p (P_{pm}, P_x, Y_p) = \ln Y_p - 0.15 \ln P_{pm} - (1 - 0.15) \ln P_x . \qquad (29)$$

Where Y_p = income,
P_{pm} = price of treatment
P_x = price of others goods

Assuming that

$Y_p = Y_p^{\,0}$, where $Y_p^{\,0}$ is average income of the poor
$P_{pm} = P_{pm}^{\,0}$, where $P_{pm}^{\,0}$ average price of treatment for the poor.

Let P_x represented by consumer price index in 1997 in Benin.

$Y_p{}^0 = 37,134.8$ F CFA
$P_{pm} = 996$ F CFA
$P_x = 180.44$

$$\text{Then } \ln V_p (P_{pm}, P_x, Y_p) = \ln(37,134.8) - 0.15 \ln(996) - (1 - 0.15)\ln(180.44)$$
$$= 10.52 - 1.03 - 4.41$$
$$= 5.08$$

$$V_p (P_{pm}, P_x, Y_p) = e^{5.08} = 160.7$$

The utility for the rich (544.5) is higher than the utility of the poor (160.7). Otherwise if we want to achieve equity we must charge more the rich people.
A sensitivity analysis can be made; maximum utility for the rich and poor subject to a certain level of people treated or to the price of treatment. E.g. At what level we can increase the price of treatment for the rich and decrease the price of treatment for the poor such as the marginal utility for the rich equal to the marginal utility for the poor.

Marginal utility analysis

$$\ln v(p_m, p_x, y) = \ln y - a \ln p_m - (1-a) \ln p_x. \qquad (11)$$

$$\frac{\partial \ln v}{\partial p_m} = \frac{a}{p_m}$$

$$\frac{1}{v} \cdot \frac{\partial v}{\partial p_m} = \frac{a}{p_m}$$

$$\frac{\partial v}{\partial p_m} = v_0 \cdot \frac{a}{p_{m0}}$$

$$m\, v = \Delta \partial v / \Delta \partial\, p_m$$

Where mv is the marginal (indirect) utility function. This marginal utility is evaluated at initial level v_o, a , p_{m0}

To attain the equilibrium for maximization social welfare, the optimum condition is to increase the price of treatment for the rich and decrease for the poor such as:

MVr/Pmr = MVp/Pmp

Where MVr is the marginal utility for the rich
Pmr is the price of treatment for the rich
MVp is the marginal utility for the poor
Pmp is the price of treatment for the poor

Table 15 shows the result of marginal utility analysis (by using the hypothetical data.)

Table :15 Marginal utility analysis

Vr**	MVr	Pmr	MVr/Pmr	Vp**	MVp	Pmp	MVp/Pmp
547.3202*	-	998*		109.0013*		996*	
543.3181	4.0021	1097.8	0.0036455	110.7415	1.7402	896.4	0.0019413
539.6901	3.6280	1197.6	0.0030293	112.7155	1.9740	796.8	0.0024774
536.3742	3.3159	1297.4	0.0025558	114.9958	2.2803	697.2	0.0032706
533.3223	3.0519	1397.2	0.0021842	117.6859	2.6901	597.6	0.0045015

* indicates the initial level
** Vr and Vp are obtained by equations (28) and (29)

This result suggests that, when the price of treatment is 1297.4 F for rich and 796.8 F for poor; MVr/Pmr ≅ MVp/Pmp.

An analysis looking at the marginal utility for the rich and poor suggests that the price of treatment can be set up at 1297.5 F and the government or / and donors should subsidy the poor about F500. . Therefore the price policy for onchocerciasis prevention should be carefully decided if we don't want people to reduce the drug consumption.

4.2 Ability to pay

From (15) $ATP = \beta_0 + \beta_1 Op + \beta_2 Ts + \beta_3 Fs + \beta_4 Sy$ (30)

By using binary choice model, logit model method of estimation we obtain the result as follow

Table: 16 Ability to Pay parameters.

Variables		Op	Ts	Fs	Sy
Coefficient	β_0 3.2	β_1 0.48	β_2 0.8	β_3 -1.6	β_4 0.34
t-statistic	2.1547**	38.8938*	3.8893**	-0.7304	4.2587**
Probability	0.0745	0.0212	0.0611	0.7516	0.0812

Remark: * indicates significant at 0.05 level
** Indicates significant at 0.10 level

The model is:

$$ATP = 3.2 + \underset{(38.89)}{0.48\,Op} + \underset{(3.88)}{0.8\,Ts} - \underset{(-0.73)}{1.2Fs} + \underset{(4.25)}{0.34Sy}$$

Ownership of property: Op

Ownership of property is positive for ability to pay without any property is negative; because the estimated coefficient of ownership of property is positive and significant at 5% level. It is the expected coefficient, because in Benin people use their assets (sell or rent) in case of serious illness. Often rich people own a lot of properties.

Type of saving: Ts

Ability to pay is correlated with savings. The estimated coefficient is positive and significant at 10% level in case of any kind of saving. Recognition is not given to the amount of savings. The result shows that, whoever has some saving has some measure of ability to pay for onchocerciasis control program. The presence of any type of saving is positive for ATP. This qualitative variable follows the same pattern in both group rich and poor. Low-income people, who have a saving, are more able to pay than those who have no saving are.

Family size: Fs

Its effect is negative. It is the expected sign, but has no effect on ability to pay for onchocerciasis control, because the p value is very high and not significant at 10%.

Source of income: Sy

Its effect is positive and significant at 10% level. When the source of income is not permanent the effect is negative. Its means when people have permanent occupation there are more able to pay for onchocerciasis control.

4.3 Willingness to pay

In this section we assume that the number a household wants to treat is equal to his willingness to pay; seeing that the amount his willing to pay is equal to the number of person his willing to treat times the price of treatment per person. Therefore, level of knowledge, priority ranking, presence of clinical onchocerciasis on one or many household members and risk of contracting onchocerciasis determine the number of people treated. Thus

$$M_i = \alpha_0 + \alpha_1 Lk_i + \alpha_2 Pr_i + \alpha_3 Rci + \alpha_4 Le_i + \alpha_5 Tc_I \quad (31)$$

By using Ordinary Least Squares method of estimation, we obtain the result as below

Table: 17 WTP parameters

Variables		Lk	Pr	Rc	Le	Tc
Coefficient	α_0 -1.2	α_1 2.8	α_2 1.27	α_3 2.3	α_4 3.3	α_5 -0.6
t-statistic	5.4120*	5.0274*	4.3451*	4.0022	8.3457*	6.2541*
Probability	0.0012	0.0172	0.0372	0.0911	0.0004	0.0008
R-squared	0.89191					
Adjusted R^2	0.87352					
Log likelihood	- 570.3756					
F-statistic	45.1544					
Prob(F-statistic)	0.00000					

Remark: * indicates significant at 0.05 level.

All the qualitative values have an impact on the number of people treated.
$R^2 = 0.89191$. Adjusted $R^2 = 0.87352$. It means 87% of people a household is willing to treat can be explained by those qualitative factors.

Level of knowledge: Lk

Either someone has some reasonable knowledge or he/she does not. If with reasonable knowledge, the number of people he or she wants to treat increases by 2 (ceteris paribus). The estimated coefficient of level of good - knowledge is positive and significant at 5 %. Reasonable knowledge means at least middle or high knowledge according to the questionnaire.

Priority ranking: Pr

If onchocerciasis is of a sufficient priority; the number of people a household wants to treat is greater. When it is a priority, the number of people he wants to treat increases about 1.27.

Perceived risk: Rc

Any level of perceived risk is positive. When a household thinks there is no risk his willingness to pay for ivermectin is less; but when he realize that the risk of contracting the disease is high and the probability to become blind is not equal to zero he is willingness to pay increases by 2.3.

Presence of clinical onchocerciasis: Le

The presence of clinical onchocerciasis is positive for WTP. When one member of household is blind or has clinical onchocerciasis, the caretaker is highly motivated to contribute for onchocerciasis control. The coefficient is higher than other qualitative variables and the p value is very low. Therefore has a significant effect on willingness to pay. The number of person he wants to treat increase by 3.3

Transport cost: Tc

The transport cost has a negative sign. When the Tc increase by one unit the number of people he or she wants to treat decrease by 0.6.

4.4 Community involvement

Binomial logit model (Community involvement versus non community involvement). Maximum likelihood estimation results of the binomial logit model for community involvement of onchocerciasis control are presented in table 18 while table 19 presents the descriptive statistics.

Table 18 Community involvement parameters

Variables	Coefficient	Standard Error	T statistic	Probability
A_c	0.739675	0.421201	1.756111	0.0806
D_s	1.541387	0.385910	3.994166	0.0001
C_l.	1.185785	0.477074	2.713005	0.0072
I_h	0.034894	0.485018	0.071944	0.9427
P_b	1.733088	0.458923	3.776424	0.0002
C	-1.962930	0.510151	-3.847745	0.0002
Log likelihood		-92.92591		
Obs with Dep 1		153		
Obs with Dep 0		59		

Table: 19 Descriptive statistics of CI

Variables	Mean all	Mean D = 1	Mean D = 0
A_c	0.396206	0.477124	0.186441
D_s	0.660377	0.771242	0.372881
C_l	0.448113	0.529412	0.237288
I_h	0.783019	0.849673	0.610169
P_b	0.778302	0.869281	0.542373
C	1.000000	1.000000	1.000000

Household face two choices: Finds his/her community involved in onchocerciasis control or not. All the estimated coefficients are relative to community involvement. As expected, the estimated coefficients have the priori expected signs and most are statistically significant at 10% level or less. The findings emanating from an analysis of table 18 are as follows.

Availability of credible distributor: A_c

Its effect is positive and significant at 10% level. It suggests that the log-odds in household decision of finding his or her community involved in onchocerciasis control increase about 0.73 or 73 % as there is credible distributors in the community; if others factors remain the same. This result is consistent, because bad character and criminal behavior impaired operations of the ivermectin distribution. Also multi-countries studies (WHO/TDR, 1996) show that by selecting individuals who are perceived to be credible, the communities are able to identify with the program, and it is a good indicator for sustainability.

Flexibility to change the distribution system. D_s

It effect is positive. The coefficient is 1.54 and significant at 5 % level. This result indicates that when household knows their initial mode of distribution can be changed, when found to be inconvenient or inadequate to alternatives that worked better for them, they are able to participate to onchocerciasis control.

Community leadership C_l.

Even though the style of leadership varied, good leadership is an important determinant of successful community involvement. The coefficient is positive and significant at 5 % level. It suggests that the log-odds in household decision of finding his or her community involved in onchocerciasis control increase about 1.18 or 118 % as there is community leadership. This result is similar to TDR study (1996), which shows that leadership is necessary to motivate people to participate in the program and to follow up when necessary to ensure their community received ivermectin.

Integration With local health system: I_h.

The coefficient is positive, but the p value is high, therefore not significant. The integration with local health system has no effect on community involvement.

Perceived benefits of ivermectin: P_1.

Its effect is positive and significant at 5 % level. Its coefficient indicates that the log-odds in favor of community involvement increases of about 1.73 or 173 % if household considered ivermectin a helpful drug. The magnitude of this estimated coefficient is consistent with community involvement and sustainability of onchoerciasis control program.

Correlation analysis of the independent variables

The correlation analysis measures the degree of association between the variables. It will be generated to detect independent variables, which are correlated with other independent variables. All the above estimations don't have the problem of multicollinearity because in the study the number of observation is large enough. But in case of serious multicollinearity it will lead to large standard errors of the estimators. However we can solve this problem by dropping one variable; this leads to a rational choice of only relevant independent variable for the final model. It is also possible that in other sample involving the same variables collinearity may not be so serious as the first samples. Sometimes simply increasing the size of the sample (if possible) may attenuate the correlation problem. We can also transform the variable in other form of the unit. Of course, which of these rules will work in practice will depend on the nature of the collinearity problem.