Business & Social Science
IJRBS

Research in Business & Social Science

IJRBS VOL 10 NO 3 ISSN: 2147-4478

Available online at www.ssbfnet.com
Journal homepage: https://www.ssbfnet.com/ojs/index.php/ijrbs

Marginal rate of substitution of multidimensional well-being for affected residents of the dam, Pak Mun Dam

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ARTICLE INFO

Article history:

Received 22 March 2021
Received in rev. form 18 April 2021
Accepted 24 April 2021

Keywords:

Marginal rate of substitution, multidimensional, well-being, Pak Mun Dam, water management, Thailand

JEL Classification:
G31, G23

ABSTRACT

The marginal rate of substitution shows that negatively affected residents of Pak Mun Dam are willing to trade three units of economic well-being to gain one more unit of social well-being. Marginal rate of substitution (MRS) provides important information to the government regarding such trade-offs. Given the limited budget and resources, the optimal point of the combination of these dimensions of well-being should be determined in order to provide better strategy and policy to improve the conditions for residents affected by the dam's construction. Structural Equation Model (SEM) was used to find a standardized estimate of each dimension and used it for MRS calculation.

Introduction

Water resources management, electricity production and flood protection are just a few essential functions of a dam, but there are always some people who are disadvantaged by such public projects. Pak Mun Dam is one of the controversial dams that had many impacts on the local residents who live near the dam. The livelihood of the affected community has changed in the 26 years since the dam opened. According to Chaiyamart et al. (2021), the affected and unaffected communities had differences in all three main dimensions of well-being—economic, social and environmental well-being—after the dam opened. Previous studies have examined the qualitative negative impact to local residents. The closing of the sluice gate has had a negative economic impact; while many residents still can fish, fishing production is now only 20-40% of what it once was (Manorom, 2006). Furthermore, community well-being has also been changed, as many residents were moved from their land before the dam opened and many of them were not placed in the same community, resulting in the loss of their social network and social relations (Amornsakchai et al., 2000).

Other aspects of well-being also changed for the affected residents. Working well-being decreased as affected residents lost their fishing jobs due to the lower of fish quantity that was caused by the dam. Many of them had to work in farming or in other jobs that did not fit with their previous work experience (Kiguchi, 2016). Family is also one of aspects of well-being that affected residents, as younger residents had to find jobs in the city and left the seniors behind (Kiguchi, 2016). Moreover, cultural well-being also changed because the dam was built next to the river that the community used for Thai New Year and many religious events. The affected communities could not continue their traditions as a result of the dam. Finally, the dam negatively impacted environmental well-being, which is considered an important dimension for sustainable development. With regard to the amount of fish and the numbers of different fish species around that area, there were lower numbers of fish species because they left the Mun River (Manorom, 2006).

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https://doi.org/10.20525/ijrbs.v10i3.1134

Since issues regarding Pak Mun Dam still exist and solutions have not yet been provided to improve the livelihood of the affected community, it is important to understand the impacts of the three main dimensions of well-being (economic, social and environmental) to overall life well-being and how the community can optimize these three dimensions based on sustainable development goals to achieve a sustainable livelihood with update information. Furthermore, marginal rate of substitution (MRS) can provide the information for trade-off analysis for the government to provide the better solution to improve the affected people's quality of life. Structural equation model (SEM) was used in this study to find standardized estimate of each dimension and calculate the MRS value.

Literature review

This study draws on three theories that correlate with each other: well-being, sustainability and the marginal rate of substitution.

Well-being

The concept of well-being was developed based on the theory of Sen's Capability Approach (CA), which was popular during the 1980s with regard to human well-being. Sen's approach focuses directly on quality of life, since his theory proposes that humans' quality of life can be measured through functioning, which includes "being and doing," and individual capacity, which refers to the set of functions that a person can access. This forms the foundation for multidimensional well-being, since there are many functions and capacities that are important to, and can represent, the whole of well-being. Gasper (2002) has criticized Sen for not including other important values that motivate human action such as feelings for other people (empathy) and commitment to feelings beyond personal well-being. Indeed, Sen only mentioned basic needs, physical matter and social aspects in achieving higher life satisfaction (utility).

According to Kahneman (2002), well-being comprises two areas: objective well-being and subjective well-being. Cahyat et al. (2003) define the conditions of objective well-being as core well-being—basic needs in terms of material, wealth, knowledge and health; sectional environments, such as the natural, economic, political and social spheres; and intersectional environments, including infrastructure and services. On the other hand, subjective well-being is internal and intangible. Kahneman (2002) identifies emotional well-being, or life satisfaction, through positive emotions such as joy, happiness and pride, and negative emotions such as pain and worry.

When considering how to evaluate well-being, it is important to consider both objective well-being and subjective well-being. This study is based on the multidimensions of well-being, which are described in the following paragraphs.

First, economic well-being is one of three pillars of well-being for sustainable development. Economic activities bring a better quality of life through higher income and greater consumption of basic needs (e.g., food, health care and shelter) as well as luxury products. There are many indicators for economic well-being, such as income level (Smith & Summers, 2011). Osberg and Sharpe (2003) use economic insecurity, such as saving less or having debt, as an indicator of economic well-being; they also discuss the stock of wealth or material wealth that people own. Besides income, Smith and Summers (2011) also use household productivity value, which includes farming and harvest yield. In addition to these tangible indicators, Prawitz et al. (2006) consider the emotions, feelings or worries individual people or households have regarding their economic conditions as a subjective indicator of economic well-being.

Second, social well-being is another pillar of sustainable development. Social well-being involves several aspects: community well-being, political well-being, health well-being, job well-being, cultural well-being and family well-being.

Community well-being considers how human well-being is a process of public and private production. Being part of a society, or being accepted by a community, is crucial for humans to achieve their basic social needs. There are many indicators for community well-being, such as social relationships, the feeling of being part of community and the feeling of being supported by society (Cahyat et al., 2007). Smith and Summers (2011) note that the feeling of being connected by sharing the same interests, the same culture and the same identity is a crucial indicator. Furthermore, Cahyat et al. (2007) identify the feeling of being acknowledged and respected, and the level of trust community members have in each other, as important indicators. Social participation is also used as an indicator of community well-being because it creates social capital as well as a rewarding feeling of contact with other people and being part of society (Putnam, 2000). Moreover, the feeling of being safe or having freedom from harm within the community is also crucial indicator for community well-being (Rahman et al., 2003).

Health well-being considers how human capital is critical for a nation's development, as a lower quality of human capital leads to lower levels of production and national wealth. The quality of human capital depends not only on levels of education but also on health status. Good health indicates the condition of being able to learn and work more efficiently. Health well-being can be measured in many ways; health conditions can be categorized into physical health well-being and mental health well-being. Physical health well-being can be indicated through hospital check-ups and self-reporting on exercise, smoking and diet. Mental health well-being can be indicated by depression and mood disorders (Keyes, 2006).

Political well-being relates to everyone because government policies directly impact their people. People should be able to rule, control and protect their own rights, and vote for their own benefits from the government. According to Deueulin and McGregor (2010), people have the capacity to request freedom and equal treatment. Guisan (2009) mentions that a government's level of

transparency, which indicates a lack of corruption, can be considered a relevant factor as well. Cahyat et al. (2007) also suggest that efficient government services would help achieve income redistribution and economic stabilization.

Job well-being is important because jobs and workplaces represent an important part of human well-being. Having a job provides many positive mental impacts, such as high self-esteem and self-worth. Unemployment negatively impacts well-being, as unemployed persons tend to experience pressure and depression (Mendes & Saad, 2011) and often feel financially insecure, resulting in lowered self-esteem. Lehmkuhl (1999) supports the idea that an individual with good working conditions and positive job experiences would have an increased job well-being. Schaufeli and Enzmann (1998) also support the notion that work satisfaction is a key factor of job well-being.

Cultural well-being is important because culture represents the identity of the community; it is what people have lived with and it is part of their everyday life. Culture consists of complex patterns of behavior that evolve over time and define any group. It includes manners, social codes, taste, food, dress, attitudes, politics and how people respect others. Culture increases social well-being because it allows people to come together and increase their sense of connection. According to Collier et al. (1997), culture increases feelings of belonging and pride in traditions and heritage. Salvaris (2007) also mentions that cultural programs provided by the government can be used as an indicator for cultural well-being, as such programs allow for people to pass their culture on to the next generation.

As the smallest but most important unit in society, family provides a strong foundation for the community. Family well-being is based on the relationships between family members. According to Martinez (2003) many indicators shape a person during childhood, including parenting. There are two family functioning theories that have been used to measure family well-being. The first theory was based on the Circumplex Model of Marital and Family Systems (Olson, 1999), which is comprised of three main areas: family cohesion, family flexibility and family communication. The second theory is the McMaster Model of Family Functioning, which is similar to the Circumplex Model of Martial and Family Systems but includes more details, such as problem solving, affective responsiveness and affective involvement.

Finally, environmental well-being is one of the three pillars of sustainable development. The environment impacts humans because nature provides basic human needs such as clean water, clean air, sources of medicine and food. Negative changes to an ecological system can eventually be harmful for humans and production. Many previous studies have mentioned multiple indicators to measure environmental well-being. Smith and Summers (2011) recommend three measurements for this dimension: functional stability, functional redundancy maintained and habitat heterogeneity. Osberg and Shape (2003) emphasize the quality of the environment, especially the quality of water for consumption. Smith and Summers (2011) suggest that measurements of this dimension can test whether water is potable, swimmable and fishable. Rishi and Khuntia (2012) note that the temperature level can cause health problems. Furthermore, environmental enhancement projects such as recycling programs and environmental improvement programs are also indicators for environmental well-being.

Sustainability

Sustainability has become an important concept as people have recognized that environmental changes have resulted in many forms of negative impacts on humans, including their health, production and food. Since the world's resources are limited and the population is increasing, the current rate of utilizing resources is likely to result in insufficient resources for the generations to come.

There has been serious discussion of sustainability, which started with the concept of having to efficiently utilize resources for the current period while also maintaining a sufficient amount of resources for new generations. It is crucial to achieve the main three pillars of sustainability: economic, social and environmental sustainability.

Marginal rate of substitution and well-being

Utility and utility function

Utility is the level of satisfaction and $U(x_1,x_2) = A$ is the utility function, where A represents a constant utility(level of satisfaction) along an indifference curve. The utility function measures the level of satisfaction for consuming a set of goods or resources.

Marginal Utility represents the change of satisfaction level when the number of goods has been additional consumed by one unit.

$MU_x = \Delta U / \Delta X = \partial U / \partial X$ is equal to the slope of the utility function. Once product X has been added, keeping other goods and resources constant. The satisfaction that has been gained from consuming that unit represents the marginal utility of that unit. Marginal utility is used to calculate for marginal rate of substitution (MRS).

Marginal rate of substitution (MRS)

The marginal rate of substitution (MRS) can provide a better understanding of how people trade

between goods and services that they consume. In this study, affected residents had traded one area of well-being to gain more of another well-being dimension. This would allow us to more fully understand the relationships among well-being dimensions. Affected residents have many choices involving many different combinations of well-being dimensions. The MRS is the rate at which

an affected community is prepared to exchange well-being X_1 for well-being X_2 and maintain the same utility and happiness with different budget to fund the project by public sector.

After setting the total differential of the utility function to zero to maximize utility or happiness, the result is:

U(x,y)= A, when U(x_1, x_2) is utility function of consumption of well-being x_1 and well-being x_2 to get utility(happiness) of A.

$\frac{\partial U}{\partial x_1} dx_1 + \frac{\partial U}{\partial x_2} dx_2 = 0$

$\frac{dx_2}{dx_1} = \frac{\left(\frac{\partial U}{\partial x_1}\right)}{\left(\frac{\partial U}{\partial x_2}\right)}$

and $\left(\frac{\partial U}{\partial x_1}\right) and \left(\frac{\partial U}{\partial x_2}\right)$ are the marginal utilities of well-being x_1 and well-being x_2, respectively. Thus,

$\frac{dx_2}{dx_1} = \left(\frac{MU_{x_1}}{MU_{x_2}}\right)$

$\frac{dx_2}{dx_1}$ represents the slope of the indifference curve and is considered the $MRS_{x_1 x_2}$.

$MRS_{x_1 x_2} = -\frac{MU_{x_1}}{MU_{x_2}}$. In general, the sign of MRS is negative, since it is trading off between two goods and resources. This means that the MRS of x_1 for x_2 indicates the amount of well-being x_2 given up to gain one more unit of well-being x_1. The MU_{x_1} and MU_{x_2} are the estimate coefficients for each product that is consumed in the utility function which can be estimated during structural model (multiple regression) of structural equation model.

Research and Methodology

The MRS allows for a fuller understanding of how well-being and asset accumulation are affected by policy, as the MRS provides an understanding of trade-offs. To accomplish this objective, a standardized estimate for each of the three main well-being dimensions must be made. This can be achieved through Structural Equation Modeling (SEM). Since latent variables are not measured directly from this study's survey, SEM would be an appropriate method to estimate the standardized coefficient for this study. Since latent variables cannot be represented by only one factor, SEM would allow for the combination of measured items into the same latent variables.

The questionnaire used a Likert scale with answers ranging from a from 1-5, with 1 being totally disagree and 5 being totally agree. The questions were related to well-being dimensions (see Table 1), which includes 40 well-being items contained within 8 latent variables. To make sure that the data collected was consistent with what needed to be collected, a pre-test was conducted. This pilot test involved 30 personal interviews with residents in villages deemed to be directly affected by the construction of Pak Mun Dam.

There are eight latent variables, but these are only first order factors. Since this study focuses on the goal of sustainable livelihood, all social-related well-being dimensions will be used to estimate the second order factors of social well-being (i.e., community well-being, political well-being, health well-being, job well-being, cultural well-being and family well-being). Diagram 1 shows the entire model that represents both the measurement model and the structural model.

Data

Two villages in the Khong Jiam district were selected for this study: Hua Hew and Hua Hai. These two villages were severely affected by the dam (Phongam, 2005). Two hundred and fifty residents were interviewed by five of staffs. The Thai dessert was rewarded to them after the survey was completed.

Measurement model and structural model in SEM

There were two parts of the SEM: the measurement model and the structural model. The measurement model is the process of confirmatory factor analysis (CFA), which is used to measure the direct impact of unobserved variables of each well-being dimension based on their observed indicators. Non-statistically significant indicators based on the evaluation of the component and model fit for each model were eliminated in this measurement model. The model fit measurements used in this study are: comparative fit index (CFI), with a value larger than 0.9 considered to be good fit; standardized root mean square residual (SRMR), with a value lower than 0.08 considered to be good fit (Hu & Bentler, 1999); minimum discrepancy divided by degree of freedom (CIM/df), with a value lower than 5.00 considered to be good fit (Marsh & Hocevar, 1985); and root mean square errors of approximation (RMSEA), with a value lower than 0.05 to be considered good fit (MacCallum et al., 1996). In addition to the goodness of fit of the model, average variance extracted (AVE) and composite reliability (CR) were used to test how well that variance had been shared within the same factor.

Table 1: Well-being dimensions with their items

Well-being Dimension	Items
Economic well-being (EWB)	1) Level of financial stress
	2) Satisfaction with financial situation
	3) Feeling about the current financial condition
	4) Cannot afford to go out
	5) Living paycheck to paycheck
	6) Worry about living expenses
	7) Confidence regarding financial emergency (finding baht 1,000)
	8) Stress about finances in general
Community well-being (ComWB)	1) Social acceptance
	2) Social integration
	3) Social assistance
	4) Safety of the community
	5) Satisfaction with community well-being
Environmental well-being (ENWB)	1) Water purchasing
	2) Availability of water
	3) Fish quality (taste)
	4) Crowdedness
	5) Environmental satisfaction based on water quality
	6) Environmental satisfaction based on fish quality
Political well-being (PWB)	1) Trust in central government
	2) Trust in local government
	3) Satisfaction with government services
	4) Satisfaction with local government services
	5) Government respect for the voice of local residents
Health well-being (HWB)	1) Number of hospital visits
	2) Stress and pressure
	3) Full of energy
	4) Sleeping difficulty
	5) Health satisfaction
Job well-being (JWB)	1) Working hours (workload)
	2) Proud of current job
	3) Job fit
	4) Job satisfaction
Cultural well-being (CWB)	1) Children's understanding of local culture
	2) Community integration
	3) Self-understanding
Family well-being (FWB)	1) Time spent with family
	2) Family help
	3) Emotional support
	4) Overall family relations

Source: Chaiyamart et al., 2021

After the measurement model was modified, the structural model (multiple regression) was applied. This model represents the correlation of each latent variable of unobserved variables (well-being dimensions) with the observed dependent variable of overall well-being. The estimated coefficient from this structural model process reveals the impact of each domain on overall well-being. The process of testing for the goodness of fit of the model is similar to the testing of the measurement model, using goodness of fit indices.

MRS calculation

In this study, the utility function comprises the well-being dimensions of economic well-being, social well-being and environmental well-being. The dependent variable is overall well-being (utility).

Overall well-being (OWB) = (Utility function=U) = $\beta_0 + \beta_1 EWB + \beta_2 SWB + \beta_3 ENWB + \varepsilon$,

$\frac{\partial U}{\partial EWB} = MU_{EWB}$ which is equal to β_1, is the standardized estimate for EWB.

$\frac{\partial U}{\partial SWB} = MU_{SWB}$ which is equal to β_2, is the standardized estimate for SWB.

$\frac{\partial U}{\partial ENWB} = MU_{ENWB}$ which is equal to β_3, is the standardized estimate for ENWB.

The calculation for $MRS_{(EWB)(SWB)} = -\frac{MU_{EWB}}{MU_{SWB}} = -\frac{\beta_1}{\beta_2}$

The calculation of $MRS_{(EWB)(ENWB)} = -\frac{MU_{EWB}}{MU_{ENWB}} = -\frac{\beta_1}{\beta_3}$

The calculation of $MRS_{(SWB)(ENWB)} = -\frac{MU_{SWB}}{MU_{ENWB}} = -\frac{\beta_2}{\beta_3}$

The MRS is an important economic concept for understanding how people make their decision to consume products from many different choices of product combinations, and how they trade the products among the consumption choices but still maintain the same level of happiness. This study also uses this concept to understand how the affected local residents can trade among economic well-being (EWB), social well-being (SWB) and environmental well-being (ENWB) to maintain the same level of happiness and reach the highest happiness based on the limit budget.

Results

Measurement model result

The first part of the structural equation model is the measurement model, which groups the items that correlate to each other into the same latent variable. The items with lower loading have been eliminated from the latent variable. The latent variable that does not meet the appropriate value for average variance extracted (AVE) and composite reliability (CR) have also been eliminated. Table 2 shows that the HWB latent variable has very low AVE (lower than 5) and CR lower than 0.7, so this HWB was eliminated.

Table 2: AVE and CR for the original measurement model

Factor	**Measurement Model**			
	Original		Modified	
	AVE*	CR*	AVE*	CR*
Economic well-being (EWB)	0.605	0.828	0.562	0.836
Community well-being (ComWB)	0.424	0.530	0.374	0.540
Environmental well-being (ENWB)	0.338	0.462	0.549	0.708
Political well-being (PWB)	0.573	0.726	0.678	0.808
Health well-being (HWB)	0.390	0.477	–	–
Job well-being (JWB)	0.644	0.773	0.679	0.861
Cultural well-being (CWB)	0.759	0.803	0.577	0.803
Family well-being (FWB)	0.709	0.802	0.503	0.801

* AVE = average variance extracted; CR = composite reliability; Note: AVE and CR values for each factor in the original and modified measurement models; *Source:* Chaiyamart et al., 2021

After HWB was eliminated, the modified measurement model had the better model fit for all model fit indices compared to the original measurement model. The latent variables from this modified measurement model was used in the structural model as well.

Table 3 shows the items that have high loading during the CFA of the measurement model, which fit within the same latent variables. CFA consisted of 20 items grouped into 7 well-being dimensions. All of the factor loadings that were free to vary had statistically significant loading on their respective well-being dimensions. The t-value of 1.00 for some items was set to 1 in order to identify the model.

Table 3: Result of Seven Well-Being Dimensions Impacting Overall Well-Being *(Chaiyamart et al., 2021)*

Parameter		Standardized	SE	T-value
EWB→ Feeling about current financial condition		0.722**	0.096	9.951
EWB → Level of financial stress		0.759**	0.105	10.305
EWB → Worry about living expenses		0.603**	0.093	8.411
EWB → Stress about finances in general		0.771	1.000	1.000
ComWB→	Community participation	0.535	1.000	1.000
ComWB→	Help from their community members	0.662**	0.214	5.046
ENWB→Level of satisfaction with the water quality of Mun River and Mae Khong River		0.710	1.000	1.000
ENWB → Khong Rivers	Level of satisfaction with the fish quality in the Mun and Mae	0.738	1.000	1.000
Political→	Overall satisfaction with local government	0.876	1.000	1.000
Political→	Trust in the local government	0.742**	0.120	7.265
Working→	Being proud of their job	0.696**	0.055	12.005
Working→	Job fits their skills, knowledge, and experience	0.852**	0.063	15.266
Working→	Level of satisfaction with their job	0.922	1.000	1.000
Culture→ temple	Their children's understanding of the importance of visiting the	0.646**	0.143	8.357
Culture→	Feeling close to the community	0.753	1.000	1.000
Culture→	They understand the importance of visiting the temple	0.747**	0.112	9.105
Family→ Time spent with family has increased in the past 10 years		0.671**	0.161	7.877
Family→ Individuals turn to each other for help when something is troubling them		0.644**	0.133	7.656
Family→ Emotional support can be gained from family members when it is needed		0.727**	0.146	8.262
Family→ Overall score of family relationship		0.638	1.000	1.000

Note. **Statistically significant at ρ< 0.01; critical t-value of 2.58 used. *Statistically significant at ρ <0.05; critical t-value of 1.96.

Second order factor analysis

Social well-being (SWB) contains five dimensions: society, politics, working conditions, culture, and family. These five dimensions are first-order factors and SWB is a second-order factor. All five dimensions are statistically significant at ρ<0.01. The standardized variance of FWB was set to 1 in order to define the model. All of the second-order factors that were free to vary had statistically significant loading on SWB.

Table 4: Second Order Factor and Its First Order Factor's Loadings ()

Parameter	Standardized	SE	T-value
SWB→ Society	0.511**	0.274	3.886
SWB→ Political	0.561**	0.213	5.459
SWB→Working condition	0.517**	0.206	5.416
SWB→ Cultural	0.507**	0.170	4.885
SWB→ Family	0.691	1.000	1.000

Note. **Statistically significant at ρ< 0.01; critical t-value of 2.58 used. *Statistically significant at ρ <0.05; critical t-value of 1.96;
Source: Chaiyamart et al., 2021.

Structural model result (multiple regression)

Hypothesis testing during structural model

Table 5 shows the results of the structural model and the impact of the three main pillars of sustainability to OWB, which has predictors of EWB, SWB and ENWB and the dependent variable of OWB. The hypothesis test can be found as follows:

Hypothesis one: the impact of EWB on OWB

Results show that the standardized estimate of EWB to OWB is 0.306, with a p-value of 0.011 that is statistically significant at ρ <0.05. This shows that EWB has a positive impact on OWB. When the standard deviation of EWB increases by one unit, the standard deviation of OWB will increase by 0.306 units.

Hypothesis two: the impact of SWB on OWB

Results show that the standardized estimate of SWB to OWB is 0.921, with a p-value of 0.002 that is statistically significant at $\rho < 0.001$. This shows that SWB has a positive impact on OWB. When the standard deviation of SWB increases by one unit, the standard deviation of OWB will increase by 0.921 units.

Hypothesis three: the impact of ENWB on OWB

The results are different from the results from hypothesis one and two because the standardized estimate of ENWB to OWB has a negative sign of 0.198 but a p-value of 0.108, which is not statistically significant. The results show that there is no impact of ENWB on OWB.

Table 5: *Standardized Estimated Result of Three Pillar Well-Being Dimensions of Sustainability to Overall Well-Being*

Factor	**Standardized estimate (estimated coefficient)**	**SE**	**Confidence Interval**		***p*-value**
			Lower	Upper	
EWB	0.306	0.113	0.402	0.524	0.011
SWB	0.921	0.507	0.581	1.908	0.002
ENWB	-0.198	0.186	-0.612	0.006	0.108

Source: Chaiyamart et al., 2021

Diagram 1 shows the CFA results on the left-hand side, with items that had high loading and grouped into the same latent variables of EWB, CWB, PWB, JWB, ComWB and FWB as within the first order factor analysis. The group of CWB, PWB, JWB, ComWB and FWB were later grouped into SWB during second-order factor analysis. The impact of EWB, SWB and ENWB on OWB would be considered in the stage of the structural model.

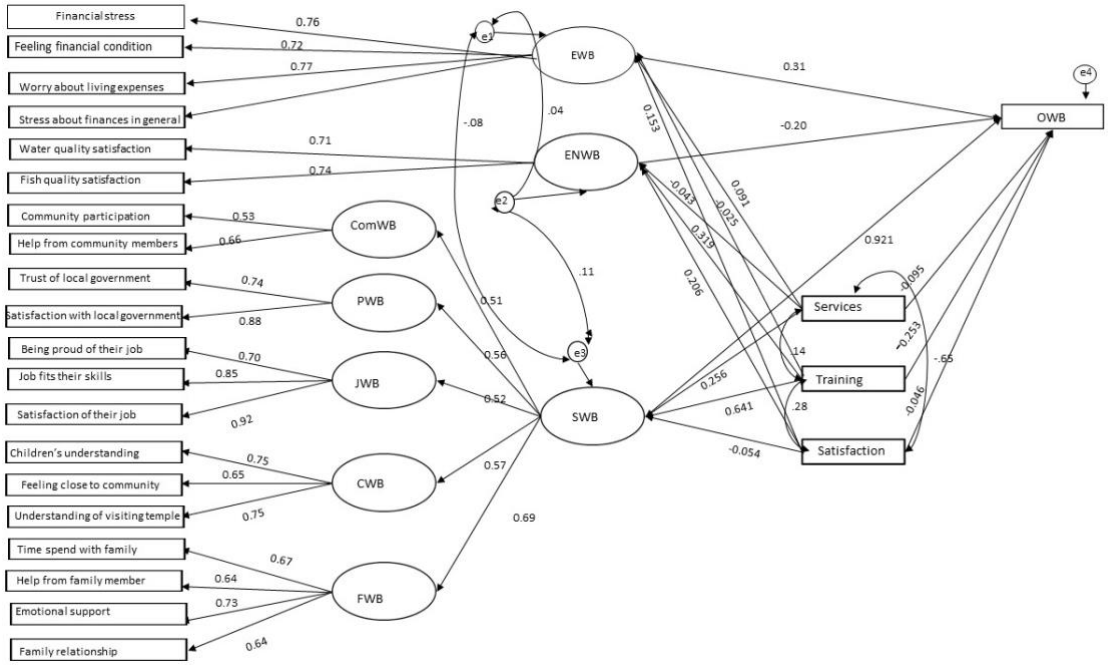

Figure 1: The full path diagram for the combination of the modified measurement model and the structural model; *Source:* Chaiyamart et al., 2021.

Based on the model fit for the structural mode, there are only two model fit indices that show mediocre fit: RMSEA and CFI. SRMR and CMIN/df show a good fit value for the structural model.

MRS result

Based on the results shown in Table 5, only two dimensions (EWB and SWB) show a statistically significant impact on OWB. The standardized estimate would show the impact on OWB, but the ratio of the standardized estimate would show the relationship between each well-being dimension. The results show that local affected residents were willing to give up more of their EWB to gain more SWB.

$MRS_{ES} = \frac{MU_E}{MU_S}$, when E = EWB and S = SWB

MU_E = Marginal utility of EWB

MU_S = Marginal utility of SWB

$MRS_{ES} = \frac{MU_E}{MUS} = \frac{dy/de}{dy/dS}$, y = OWB. And $\frac{dy}{de}$ = the standardized estimate of EWB to OWB, and $\frac{dy}{dS}$ = the standardized estimate of SWB to OWB

$MRS_{ES} = -\frac{0.306}{0.921}$ = - 0.332

From this result, SWB must give up 0.332 to gain one unit of EWB; however, EWB has to give up three units to gain only one unit of SWB.

This means that affected residents were willing to give up more EWB to regain their SWB. The results show a relationship between EWB and SWB where one can be substituted for the other, as mentioned in the literature review for the sustainable development framework. This means that gaining one well-being dimension requires lowering another dimension, which shows that residents considered SWB to be more important than EWB. This information was used to understand how each dimension would rank in importance based on the limited resources.

The MRS concept provides an understanding of the relationships of each construct (well-being dimension) within the model and how they could be traded off to achieve a sustainable livelihood based on limited capital or resources. The MRS can also be used to explain the level of a community's sustainability based on the relationships of economic, social, and environmental well-being. This information would help allocate resources more efficiently in order to reach the goal of sustainability, and is based on information regarding a real understanding of sustainability for the local community.

Discussion

The impact of EWB, SWB and ENWB on OWB

EWB and SWB have statistically significant impacts on OWB. Based on the standardized estimate of these predictors, SWB has a stronger impact on OWB than EWB has. This shows that local residents consider social well-being to be important to their life; changes in their livelihood are considered crucial and EWB might not be the most important anymore. The results from the measurement model supports the qualitative study of Manorom (2006) and Kiguchi (2016), showing that EWB and SWB have statistically significant impacts on OWB. Of those 18 items, 4 of them are in the EWB dimension and 14 items are in the SWB dimension.

EWB (4 items) all relate to subjective well-being in that the residents worried about their financial condition due to the dam's completion. The significant change affects their livelihood; they do not have sufficient income to support their families. Without a permanently open dam, they do not seem to be able to earn sufficient income or have enough food.

Of the 14 items of SWB, 5 are first-order factors: ComWB, PWB, JWB, CWB and FWB. Community participation and help from other community members play important roles in ComWB because all of community members face the difficulty of living with economic sufficiency, and it is difficult for them to help each other.

The results show that understanding cultural traditions and the meaning of their traditional activities plays an important role in CWB. Many traditions for these communities relate to the river, such as Thai New Year (Phongam, 2005).

Trust and satisfaction of the local government are important items for PWB because the local government was very close to the community. The local government would be the first point of contact for the affected community, and they had been with local residents since the beginning of the problem. The local government would be the mediator between the federal government and the local communities to find a solution for any issue.

FWB relates to family relationships; the younger generation had to move to the city to find better jobs with higher incomes so that they could send money back home to support their families. The dam caused them many negative impacts, as families spent less time together and the younger generation received less help and emotional support from their family.

The three items of JWB are related to job pride, skills and satisfaction, and they are statistically significant within JWB. After the completion of the dam, residents are not satisfied with their current work situations because their current jobs do not relate to fishing, their previous source of livelihood.

MRS

The concept of MRS demonstrates that a person will trade or give up one item of consumption in order to consume another item to maintain the same utility (i.e., satisfaction). With different MRS this would create different budgets. This study's results prove that EWB may not be the only factor that concerns the affected community; the residents are willing to trade EWB for other dimensions of well-being.

The coefficient of SWB is larger than the coefficient of EWB. The affected community would trade their EWB to gain more in other nonfinancial dimensions, which is SWB. For 26 years, residents have been asking the government for financial compensation and to open the dam gate to enable them to return to their sustainable livelihood (Manroot & Hall, 2009). Not only does EWB need to be achieved, but social and environmental aspects are necessary as well. The qualitative work has been done, but quantitative work regarding the relationship between OWB and other dimensions of well-being has not yet been conducted. The coefficient of each dimension to OWB would show the relationship between OWB and each dimension, but the relationships between the dimensions themselves must use the MRS.

The MRS shows how important SWB is and how it compares to EWB. This information would support policy and future projects to help the affected community improve its social conditions, especially SWB and EWB, for which they have requested assistance. The model shows that residents are willing to trade a lower EWB to gain more SWB. Based on the MRS concept of trading among objects to maintain satisfaction, there must be combinations of these two well-being dimensions that reach an optimal solution.

The results also indicate that SWB was lacking in the past because the residents were willing to decrease their EWB to gain one more unit of SWB. This could be explained using the concept of opportunity cost: to gain more resources in lesser supply, other, more plentiful resources would need to be given up. This supports previous qualitative work that showed that SWB had been lacking because it existed in smaller amounts, or because it was less readily available than EWB. EWB was not provided at a sufficient level either, but SWB was still much lower. Furthermore, this benefit would support the quantitative information that was not provided for studying SWB and EWB over time. This quantitative work has provided a better understanding of this community regarding livelihood development. How can this information be used? An institute or structure can play a key role in sustainable development, as an institute can collect all capitals for each dimension to create a more sustainable livelihood.

To support qualitative work, quantitative results have shown these communities' well-being through many dimensions. Regression analysis has revealed which factors statistically significantly impact OWB, which provides information on how the affected community considers the factors (dimensions) that are important for their decisions. This quantitative result provides solid evidence for determining better policies to achieve the goal of sustainability for these communities. Moreover, understanding the MRS and its usage would help us to understand the process of trading based on the limited resources.

There are still positive impacts of EWB and SWB on OWB. The MRS of EWB to SWB has confirmed that, with limited resources, there is a trade-off among the dimensions to maintain the same satisfaction in a person's livelihood and this is the highest satisfaction that they can reach.

Trade-off analysis can use this information to create a better strategy for the government, since the budget of the government is limited. After protests for opening the gate for fish to be able to return to the Mun River, residents requested that the government open the gate permanently. The government decided to try it out for only four months. The MRS analysis provides possible options that the government could use to improve the quality of life of for affected residents, for example, by opening the sluice gate and funding other projects based on the MRS information and the statistically significant of items in SWB and EWB. The budget of funding to improve quality of life of these affected residents along with the possibility of opening the sluice gate of the dam must follow the ratio that the affected residents are willing to give up three units of EWB to gain one more unit of SWB.

Future studies could focus on the role of the government, the private sector or stakeholders and their projects for increasing capital for the well-being dimensions, or on the possible combinations of well-being levels, especially for SWB and EWB, and considering which projects would be appropriate for maintaining the residents' livelihoods.

In terms of this study's limits, this study could not include ENWB because it did not have a statistically significant impact on OWB, at $\rho < 0.05$. Since ENWB is crucial, and it this well-being dimension that would eventually improve EWB and SWB, it would be important to have further discussions regarding the MRS between these three main well-being dimensions of sustainable development.

Conclusion

The MRS results from the SEM can explain the relationship of each well-being dimension and provide greater understanding of the impact of each dimension on OWB, along with estimated coefficients of each dimension to OWB. Items that have high loading for each dimension also provide an understanding of the important factors for each well-being dimension and OWB. Moreover, the results of this study show that residents would trade three units of EWB to gain one more of SWB, which would help decision making by conducting trade-off analyses for many sustainability or ecosystem projects to improve the quality of life of these affected residents.

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