



Testing Theories about the Composition of GNH Domains and Subsequently Building Causal Models by Means of Structural Equation Modeling

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Abstract: GDP, a yardstick designed to measure the progress of the economies of the world's industrial nations after World War II has been instrumental in rebuilding the economies in the past, but now it is causing as many problems as it solves. Many questions have been raised about GDP: Increasing self-reliance means decreasing GDP; GDP doesn't correlate with quality of life measures; GDP doesn't account for the distribution of costs and benefits. It was against this backdrop of inadequate measure that GNH was proposed as an alternative measure of development. Therefore, the larger aim of this paper is to build a methodology to construct GNH domain-specific quantitative indicators (objective and/or subjective) and then develop a single GNH indicator from the domain-specific indicators. To achieve this, observable variables thought to belong to a specific domain according to prior theories or notions are grouped together. A latent variable has been identified and suitably renamed. Subsequently, implemented causal modeling amongst/between them—evaluated model fitness, validated the relationships and finally a decision is made about the prior notions or theories of the composition of GNH domains using the GNH survey data of the year 2010.

Keywords: Modeling, causality, confirmatory, analysis, latent, manifest, happiness.

I. INTRODUCTION

Gross Domestic Product popularly known as GDP is the market value of all officially recognized final goods and services produced within a country in a given period [1]. Although it was purely designed to measure the market value of production that flows through the economy, it became the main tool for measuring the welfare of an economy [2]. While it has led to improved standard of living, it has also caused social exclusion, poverty, misery, environmental pollution and degradation, etc.

Pained by these grievous consequences, the Government of Bhutan adopted Gross National Happiness widely known as GNH as its development philosophy. This philosophy is premised on the belief that citizens' happiness is more important than the economic development [3].

While GDP is a sum of Consumption (C), Investment (I), Government Spending (G) and Net Exports (X-M); GNH is a sum of its 9 domains [4], namely Economic development, Psychological, Emotional, and Spiritual well-being. Symbolically;

$$GDP = C + I + G + (X - M); \text{ while}$$

$$GNH = \text{Psychological Well-being} + \text{Health} + \text{Education} + \text{Culture} + \text{Time Use} + \text{Good Governance} + \text{Community Vitality} + \text{Ecological Diversity and Resilience} + \text{Living Standards}$$

Statistics on GNH domains are vital as in the case of GDP if we were to operationalize GNH development philosophy or to incorporate it into development plans and programs. In an effort to achieve this goal, the Bhutanese Government identified 9 happiness and well-being domains as GNH domains. The domains are conceptually broken down into 32 observable indicators to help determine or quantify the domains. The Government designed a GNH questionnaire and carries out a survey on yearly basis to collect data pertaining to these indicators. All responses are given a score and the raw scores are used to interpret the associated GNH domains and indicators themselves. Correlational analysis is performed to study causality among the domains and indicators.

But the problems with the present method are: First, it assumes based on prior notions that only certain set of indicators (observable predictors/measurable variables) have influence on certain GNH domains (latent factors), but no scientific study was carry out to test the causation between these observable indicators and latent factors. Second, correlational analysis is used to study causality between observable indicators but correlation doesn't imply causation, hence this is a fallacy.

The rationale behind this paper, therefore, is firstly to confirm the assumption made while identifying GNH domains, clustering indicators, and defining causal relationships; and secondly to investigate the causal relationships between latent factor(s) and measurable variables. GNH survey data of the year 2010 is used in this study.

II. GNH SURVEY PROCESS

The Centre for Bhutan Studies has designed a questionnaire to collect data pertaining to the observable indicators of GNH domains. The survey is a regular event in Bhutan and it relies on live interviews. Data used in our research were from the GNH survey of the year 2010. A total of 7142 randomly sampled respondents were interviewed from all 20 districts of Bhutan out of which the data of 6476 or 90.7% of the respondents were found to be adequate to include in the analysis.

III. CONCEPTUAL FRAMEWORK OF GNH DOMAINS

A. Concept of GNH Domains:

a. Psychological Well-being: Generally defined as nothing else but an emotion, a long-term sense of emotional well-being and contentment.

b. Health: Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, defined by World Health Organization.

c. Education: A holistic education that extends beyond a conventional formal education framework to reflect and respond more directly to the task of creating good human beings.

d. Culture: A resource for establishing the identity of a country, cushioning a country from negative impacts of modernization, and enriching a country spiritually.

e. Time Use: A good balance between paid work, unpaid work and leisure.

f. Good Governance: According to OECD, good governance is characterized by participation, transparency, accountability, rule of law, effectiveness, equity, etc.

g. Community Vitality: It is characterized by strong, active and inclusive relationships between residents, private sector, public sector and civil society organizations that work to foster individual and collective well-being.

h. Ecological Diversity and Resilience: The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.

i. Living Standards: The level of wealth, comfort, material goods and necessities.

B. Multidimensional Measure of GNH Domains:

Theoretical set of measures (indicators) to tap key dimensions of each of 9 GNH domains.

a. Psychological Well-being:

a) Life satisfaction: This indicator combines individuals' subjective assessments of their contentment levels with respect to health, occupation, family, standard of living and work-life balance. The respondents were asked to respond how satisfied or dissatisfied they were in these five areas on a five-level Likert item (1 = very dissatisfied, 5 = very satisfied) of a Likert scale.

b) Emotional balance (positive and negative emotions): Two sets of five self-reported emotional items each were selected for this indicator. One set consists of positive emotions, or non-disturbing emotions, namely compassion,

generosity, forgiveness, contentment and calmness while the other set consists of selfishness, jealousy, anger, fear and worry. The respondents were asked to rate the extent to which they have experienced these emotions during the past few weeks with reference to a four-level scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often).

c) Spirituality: This indicator covers the respondent's self-reported spirituality level, the frequency with which they consider *Karma*, engage in prayer recitation, and meditation. The responses were rated on a four-level scale of 'regularly' to 'not at all' and 'very spiritual' to 'not at all' in the case of spirituality level.

b. Health:

a) Self-reported health status: This simple self-reported indicator proxies objective health and nutrition states, and the extent to which it is affected by adaptive preferences. The ratings range on a five-level item scale from having 'excellent' health to 'poor' health.

b) Healthy days: This indicator reports the number of 'healthy days' a respondent enjoyed within the last month.

c) Long-term disability: Respondents were asked whether they had any longstanding illness that had lasted over six months. If the answer was 'yes,' they were then asked, using a five-level item scale, whether the disability restricted their daily activities. The scale ranged from 'never' to 'all the time.'

d) Mental health: This indicator consists of twelve questions that provide a possible indication of depression and anxiety, as well as confidence and concentration levels. Likert scale with lowest score at 0 and highest possible score at 36 was used to calculate and interpret it.

c. Education:

a) Literacy: Respondents are said to be literate if they were able to read and write in any one language, English or national language.

b) Educational qualification: This indicator includes formal schooling, education imparted by monastic schools and non-formal education.

c) Knowledge: This indicator captures responses to knowledge of local legends and folk stories, knowledge of local festivals, knowledge of traditional songs, knowledge of HIV-AIDS transmission, and knowledge of the Constitution. The responses are rated on a five-level item scale which ranges from 'very good knowledge' to 'very poor knowledge.'

d) Values: Respondents were asked whether they considered five destructive actions of killing, stealing, lying, creating disharmony in relationships and sexual misconduct to be justifiable. The responses are rated on a three-level item scale that ranges from 'always justifiable' to 'never justifiable.'

d. Culture:

a) Language: This indicator is measured by a self-reported fluency level in one's mother tongue on a four-level item scale.

b) Artisan skills: Respondents were asked if they possessed any of the thirteen arts and crafts skills. The thirteen arts and crafts include: weaving, embroidery, painting,

carpentry, carving, sculpture, casting, blacksmithing, bamboo works, goldsmithing and silversmithing, masonry, leather works, and papermaking.

c) Socio-cultural participation: Respondents were asked the number of days they participated in socio-cultural activities within the past 12 months and recorded the responses on a five-point scale ranging from 'none' to '1 to 5 days' to '+20 days.'

d) 'Driglam Namzha' (the Way of Harmony): Respondents were asked to rate the importance of expected behavior on a three-point scale of being 'very important' to 'not important.'

e. Time Use:

a) Working hours: This indicator assesses overworked people by asking them the number of hours they work a day. Eight hours a day is a legal limit.

b) Sleeping hours: Eight hours sleep a day is considered the amount necessary for a well-functioning body for everyone. Respondents are asked the sleeping hours a day.

f. Good Governance:

a) Political participation: The measure of political participation was based on two components: the possibility of voting in the next election and the frequency of attendance in community meetings. Respondents are asked if they would vote in the next general election and the responses are rated on a scale with a level-item 'yes,' 'no,' and 'don't know.'

b) Political freedom: The seven questions related to political freedom ask people if they feel they have: freedom of speech and opinion, the right to vote, the right to join political party of their choice, etc.

c) Service delivery: Respondents are asked on the following: distance from the nearest health care centre, waste disposal method, access to electricity and water supply and quality.

d) Government performance: Respondents are asked to rate the performance of the government in the past 12 months on seven major objectives of good governance: employment, equality, education, health, anti-corruption, environment and culture. The responses are ranked based on a five-point scale from 'very good' to 'very poor.'

g. Community Vitality:

a) Social support: Respondents are asked about the number of days they volunteered and the total amount of money they donated in the past 12 months.

b) Community relationships: The two components of this indicator are 'a sense of belonging' which is rated on a scale that ranges from 'very strong' to 'weak,' and 'trust in neighbors' which is rated on a scale ranging from 'trust most of them' to 'trust none of them.'

c) Family: Respondents are asked six question on a three-point scale of 'agree,' 'neutral' and 'disagree.'

d) Victim of crime: Respondents are asked whether they have been a victim of crime in the past 12 months. The responses are recorded either 'yes' or 'no.'

h. Ecological Diversity and Resilience:

a) Pollution: Seven environmental issues are shared with respondents, and then their responses are rated based on a four-point scale that ranges from 'major concern' to 'not a concern.'

b) Environmental responsibility: Respondents are sought their feelings of personal responsibility towards to environment. The responses are rated based on four-level item scale ranging from 'highly responsible' to 'not at all responsible.'

c) Wildlife: Respondents are asked two questions, one dealing with whether they consider wildlife damage as a constraint to farming. Responses are given on a four-point scale ranging from 'major constraint' to 'not a constraint.' Another pertains to the severity of damage and the respondents are asked to provide an average perceived degree of crop lost. Responses are taken on a scale ranging from 'a lot' to 'not at all.'

d) Urban issues: Respondents are asked to report their worries about four urban issues: traffic congestion, inadequate green spaces, lack of pedestrian streets and urban sprawl.

i. Living Standards:

a) Household income: Income earned by all the individuals in a household from varied sources within or outside of the country.

b) Assets: This indicator consists of appliances, livestock ownership and land ownership.

c) Housing quality: It is gauged from the type of roofing, type of toilet and room ratio.

At the end of the questionnaire respondents are asked to rate if they are deeply happy or extensively happy or narrowly happy or unhappy.

C. Fundamental Questions Regarding the Measure:

The multidimensional measure presently employed is purely hypothetical, and not an adequate measure to test and quantify conceptual theories involving latent factors.

It is very likely that indicators and domains may influence one-another reciprocally, either directly or through other indicators and domains as intermediaries. But this causal relationship can't be represented in the present method.

Further, it is hypothesized that 9 domains are uncorrelated factors and that each is influenced by a set of indicators. But the present method isn't sufficient to test such hypotheses.

Other advantages of the proposed methodology is that it is possible to define and specify model diagrammatically, and assess the fit of the model to the data and re-specify the model to achieve a better fit to the data.

IV. ANALYSIS AND MODELING STRATEGY

From the conceptual framework of GNH domains we construct hypothetical path diagrams [5] for each of 9 domains. The diagrams employ LISREL (linear structural relations) conventions, representing observed variables by Roman letters enclosed in rectangles and unobserved variables by Greek letters enclosed in ellipse and circles. Directed arrows

designate regression coefficients, and bidirectional arrows signify covariances [6, 7].

Then we specify *RAM* (reticular action model) [8] since the *sem* (structural equation modeling) function [9] we use to fit general structural equation models in R-language [10], employs *RAM* formulation of the model. *RAM* model includes two vectors of variables: v , which contains the indicator variables, directly observed exogenous variables, and the latent exogenous and endogenous variables in the model; and u , which contains directly observed exogenous variables, measurement-error variables, and structural disturbances. The two sets of variables are related by the equation

$$v = Av + u$$

Thus, the matrix A includes structural coefficients and factor loadings. The advantage of using *RAM* is that the elements of the A and P matrices can be read off the path diagram for the model, with single-headed arrows corresponding to elements of A and double-headed arrows to elements of P .

Finally, we generate parameter estimates, together with other model fitness statistics for hypothetical GNH models by implementing *sem* function that computes maximum-likelihood estimates for general structural equation models, using the *RAM* formulation of the model. The *sem* function has three required arguments, namely *ram*, a specification of the single and double-headed arrows in the model, corresponding to elements in the parameter matrices A and P ; S , the sample covariance matrix among the observed variable (indicators) in the model; and N , the sample size on which the covariance matrix S is based.

A. Experiment:

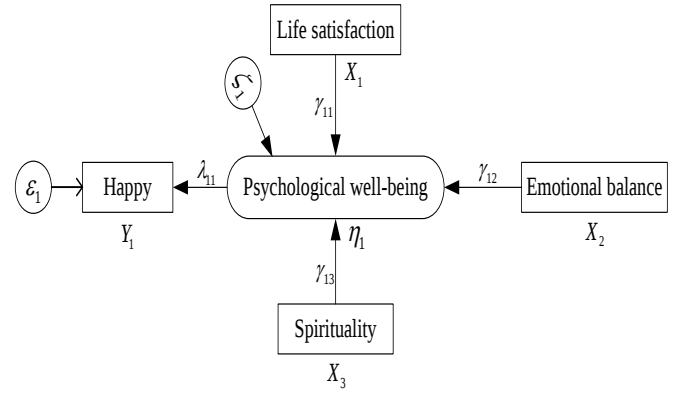
We used LISREL notation to generate structural equation model for GNH domains. The LISREL model consists of two components: a measurement model specifying how latent variables depend upon or are indicated by the observed variables, and a structural equation model specifying the causal relationships among the latent variables. The structural equation model (η_i) and measurement model ($X_i; Y_i$) are given by:

$$\begin{aligned}\eta_i &= \beta \eta_i + \Gamma \xi_i + \zeta_i \\ Y_i &= \Lambda_y \eta_i + \Gamma \xi_i + \varepsilon_i \\ X_i &= \Lambda_x \xi_i + \delta_i\end{aligned}$$

Therefore, the structural equation model and measurement model of GNH hypothetical models are defined as (shown with path diagram):

a. Psychological Well-being

a) The LISREL Model



Path diagram for Psychological Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The RAM Specification and the sem Function

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & 0 & 0 \\ 0 & 0 & 0 & \theta_{11}^e & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & \psi_{11} \end{bmatrix}$$

We used double-subscript notation for both covariances and variances. Models are estimated by computing the *sem* function using *RAM* specification, covariance matrix, and sample size.

c) Result and Discussion:

Table: 1 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.670	0.265	0.409
γ_{12}	0.510	0.423	0.18e-08***
γ_{13}	0.583	0.078	2.68e-06***
λ_{11}	0.792	0.615	9.69e-06***

Table: 2 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Psychological Well-being	556 Df=51	0.260	0.800 90%CI	301

Life satisfaction, emotional balance, and spirituality have moderate effect on psychological well-being. Happiness is strongly determined by psychological well-being.

b. Health :

a) The LISREL Model:

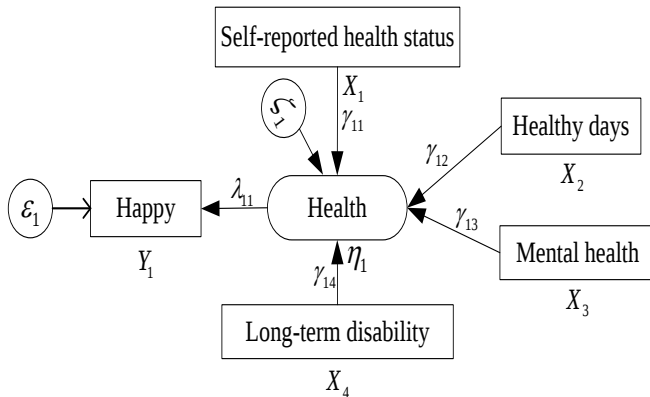


Figure: 2 Path diagram for Health Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The Ram Specification And The Sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^\varepsilon & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) Result And Discussion:

Table: 3 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.652	0.003	< 2.2e-16 ***
γ_{12}	0.213	0.001	3.425e-10 ***
γ_{13}	0.012	0.001	9.858e-15 ***
γ_{14}	0.231	0.071	0.631
λ_{11}	0.638	0.001	< 2.2e-16 ***

Table: 4 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Health	101 Df=65	0.970	0.033 90%CI	-303

All of the variables self-reported health status, healthy days, mental health, positively affect a latent factor health whereas long-term disability has a negligible effect. The resultant effect of education domain on happiness is significantly positive.

c. Education:

a) The Lisrel Model:

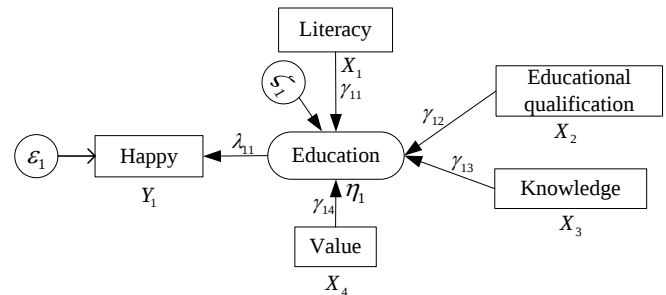


Figure: 3 Path diagram for Education Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The Ram Specification And The Sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^{\varepsilon} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) Result And Discussion:

Table: 5 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.753	0.555	7.17e-07 ***
γ_{12}	0.717	0.847	1.14e-05 ***
γ_{13}	0.141	0.144	0.325
γ_{14}	0.531	0.051	0.621
λ_{11}	0.464	0.265	3.18e-08 ***

Table: 6 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Education	841 Df=76	0.792	0.142 90%CI	368

Literacy and educational qualification significantly affects education domain, knowledge fairly affects it while value has the least effect. Education domain plays moderate role in overall happiness.

d. Culture:

a) The Lisrel Model:

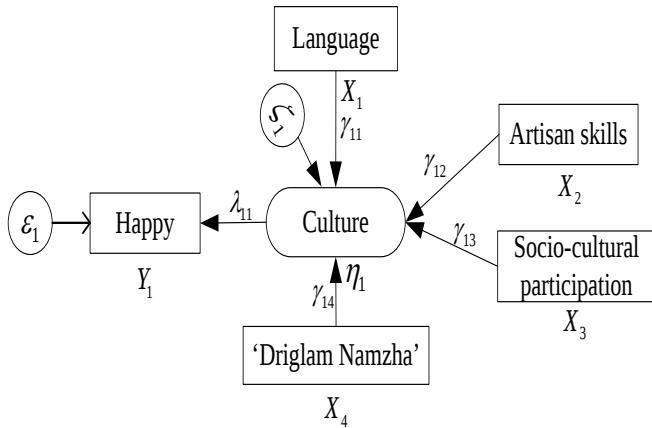


Figure: 4 Path diagram for Culture Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The Ram Specification And The Sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^{\varepsilon} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) Result And Discussion

Table: 7 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.983	0.423	2.68e-06 ***
γ_{12}	0.064	0.078	0.409
γ_{13}	0.723	0.615	9.69e-06 ***
γ_{14}	0.910	0.087	8.43e-06 ***
λ_{11}	0.610	0.787	4.44e-06 ***

Table: 8 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Culture	328 Df=72	0.882	0.084 90%CI	-120

Culture domain is highly influenced by language, socio-cultural participation and 'Driglam Namzha' while artisan skills don't have noticeable effect on it.

e. Time Use

a) The Lisrel Model:

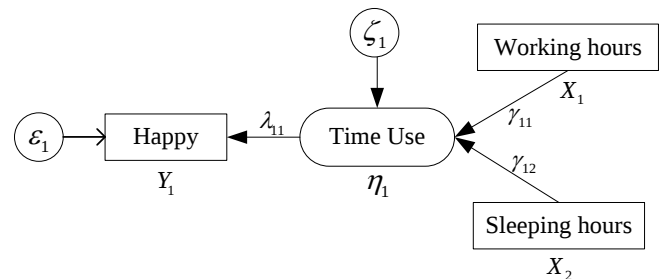


Figure: 5 Path diagram for Time Use Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The RAM Specification and the sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \lambda_{11} \\ \gamma_{11} & \gamma_{12} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & 0 & 0 \\ 0 & 0 & \theta_{11}^\varepsilon & 0 \\ \gamma_{11} & \gamma_{12} & 0 & \psi_{11} \end{bmatrix}$$

c) Result and Discussion:

Table: 9 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.614	0.155	7.07e-05 ***
γ_{12}	0.043	0.036	0.236
λ_{11}	0.102	0.063	0.103

Table: 10 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Time Use	59.7 Df =51	0.982	0.000 90%CI	-338

Working hours is important for time management which in turn is important for happiness.

f. Good Governance

a) The LISREL Model:

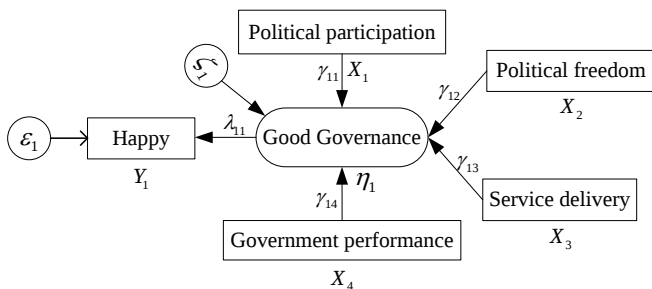


Figure: 6 Path diagram for Good Governance Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The RAM Specification and the sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \lambda_{11} \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^\varepsilon & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) Result and Discussion:

Table: 11 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.034	0.230	0.162
γ_{12}	0.064	0.070	0.109
γ_{13}	0.723	0.614	9.69e-06 ***
γ_{14}	0.639	0.002	2.05e-03 ***
λ_{11}	0.110	0.788	4.24e-06 ***

Table: 12 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Good Governance	856 Df=51	0.520	0.620 90%CI	700

The data indicate that Bhutanese people are indifferent to political participation and political freedom. They only seem to factor in service delivery and government performance in gauging good governance.

g. Community Vitality:

a) The LISREL Model:

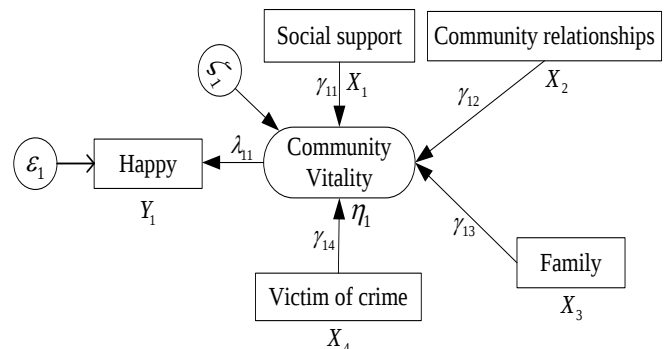


Figure: 7 Path diagram for Community Vitality Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) **The RAM Specification and the sem Function:**

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^e & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) **Result and Discussion:**

Table: 13 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.153	0.655	8.17e-07 ***
γ_{12}	0.727	0.847	1.13e-05 ***
γ_{13}	0.131	0.114	0.065
γ_{14}	0.006	0.230	0.0245
λ_{11}	0.314	0.215	2.18e-08 ***

Table: 14 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Community Vitality	758 Df=51	0.670	0.650 90%CI	654

Community possesses a strong sense of relationship amongst the community members and within families.

h. **Ecological Diversity and Resilience:**

a) **The LISREL Model:**

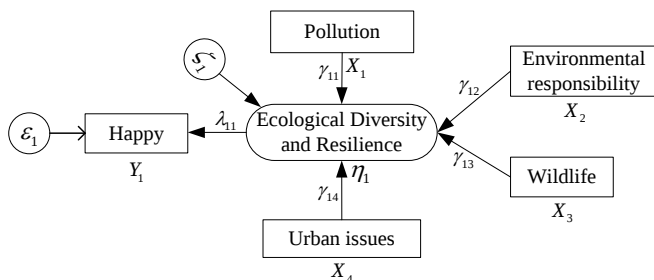


Figure: 8 Path diagram for Ecological Diversity and Resilience Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \gamma_{14}X_4 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) **The RAM Specification and the sem Function:**

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & 0 & 0 \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{11}^e & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & 0 & \psi_{11} \end{bmatrix}$$

c) **Result and Discussion:**

Table: 15 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.554	0.525	1.15e-03 ***
γ_{12}	0.126	0.148	1.11e-05 ***
γ_{13}	0.631	0.614	0.051
γ_{14}	0.551	0.005	1.02e-03 ***
λ_{11}	0.413	0.314	1.18e-09 ***

Table: 16 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Ecological Diversity and Resilience	523 Df=42	0.820	0.120 90%CI	265

The perception of environmental problems moderately relate to ecological diversity resilience domain. The respondents don't seem to be responsible about environmental issues. Wildlife and urban issues do exhibit effects on the domain.

i. Living Standards:

a) The LISREL Model:

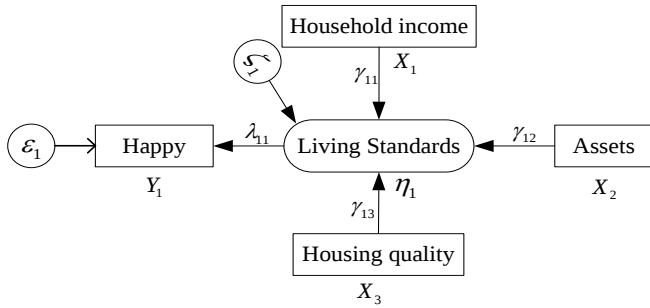


Figure: 9 Path diagram of for Living Standards Domain.

The structural equation model:

$$\eta_1 = \gamma_{11}X_1 + \gamma_{12}X_2 + \gamma_{13}X_3 + \zeta_i$$

The measurement model:

$$Y_1 = \lambda_{11}\eta_1 + \varepsilon_1$$

b) The RAM Specification and the sem Function:

$$v = Av + u$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ Y_1 \\ \eta_1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \lambda_{11} \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ Y_1 \\ \eta_1 \end{bmatrix} + \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ \varepsilon_1 \\ \zeta_i \end{bmatrix}$$

The final component is the covariance matrix P of u :

$$P = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & 0 & 0 \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & 0 & 0 \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & 0 & 0 \\ 0 & 0 & 0 & \theta_{11}^e & 0 \\ \gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & \psi_{11} \end{bmatrix}$$

c) Result and Discussion:

Table: 17 Parameter Estimates

	Estimates	Std Error	P-value
γ_{11}	0.438	0.852	0.210
γ_{12}	0.687	0.980	1.51e-05 ***
γ_{13}	0.159	0.155	0.652
λ_{11}	0.218	0.413	0.162

Table: 18 Model Fitness Assessment

Model	Chi-square	Goodness-of-fit Index	RMSEA	BIC
Living Standards	20.1 Df=51	0.880	564.000 90%CI	1054

As shown material accumulation doesn't directly translate into happiness.

V. CONCLUSION

In Bhutan, one of the main challenges to translate GNH philosophy into the government's plans and policies is the lack of adequate quantifiable indicators. In this regard, this study offers one alternative method to go about relating GNH philosophy into concrete plans and policies. At a global level, the United Nations has adopted happiness as the Ninth Millennium Development Goal (MDG) and the discourse on quantifying happiness is on-going. It is hoped that this study might help present one alternative view of quantifying it.

VI. REFERENCES

- [1] Y. Goossens, A. Makipaa, P. Schepelmann, I. Sand, M. Kuhndtand, and M. Herrndorf, "Alternative progress indicators to Gross Domestic Product (GDP) as a means towards sustainable development," European Parliament, pp. 10, October 2007.
- [2] R. Costanza, M. Hart, S. Posner, and J. Talberth, "Beyond GDP: the need for new measure of progress," The Pardee Papers, vol. 4, pp. 7, January 2009.
- [3] J. Y. Thinley, "What is Gross National Happiness?," Proc. Second International Conference on GNH in Halifax, Canada, pp. 3-11, 2005.
- [4] K. Ura, S. Alkire, T. Zangmo, K. Wangdi, "A short guide to Gross National Happiness Index," The Centre for Bhutan Studies, pp. 13, 2012.
- [5] D. Sanders, "Path analysis/causal modelling," Quality and Quantity, vol. 14, pp. 181-204, 1980.
- [6] J. O. Undheim, and J. Gustafsson, "The hierarchical organization of cognitive abilities: restoring general intelligence through the use of linear structural relations (LISREL)," Multivariate Behavioral Research, vol. 22, pp. 149-171, 1987.
- [7] B. H. Pugesek, A. Tomer, and A. V. Eye, "Structural equation modeling: applications in ecological and evolutionary biology," The Press Syndicate of the university of Cambridge, 2003.
- [8] J. J. McArdle and R. P. McDonald, "Some algebraic properties of the reticular action model for moment structures," The British journal of mathematical and statistical psychology, vol. 37, pp. 234-251, November 1984.
- [9] J. Fox, "Structural equation modeling," Lawrence Erlbaum Associates, Inc., vol. 13, pp. 465-486, 2006.
- [10] Y. Rosseel, "An R package for structural equation modeling," Journal of Statistical Software, vol. 48, issue 2, May 2012.