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The Interconnection of Water-Energy-Food and Sustainable Livelihood. A Case Study on Pinglin District in Taiwan.

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Abstract:

This study focuses on the interconnection of water energy and food nexus approach and advocate for the inclusion of sustainable livelihood into this model based on practical study of Pinglin District in Taiwan. The study applied mixed research methodology and the results of the findings shows how the construction of regional reservoir have not only affected the sustainable livelihood of economic agents in Pinglin but have also affected the cultivation of tea in the area.

Introduction

Good development practice ensures that no one is disenfranchised and left behind during the process of development (United Nations 2015, 4). The UN 2030 agenda, incorporating 17 Sustainable Development Goals (SDGs) and the 169 targets, is based upon economic, social and environmental pillars which are intended to be integrated, indivisible and interconnected (United Nations 2015, 3). In spite of recent efforts, statistics shows that the number of people experiencing severe food insecurity¹ globally has been on the rise for three consecutive years from 2014, with greater impact felt in countries where the livelihood of larger populations depend on agriculture (FAO, IFAD, UNICEF, WFP and WHO 2018, vi and 8). It is estimated that about 80% of the world population face water insecurity (Vörösmarty et al. 2010, 555) while around 1.1 billion people in the world have no access to electricity (McNamara, Nauditt, Penedo and Ribbe 2018, 8). It is projected that agriculture utilizes 70% of total water from aquifers, streams and lakes making it the largest consumer of water (FAO 2011a, 3) and 30% of the global energy supply is made use by the food sector (FAO 2011b, 2). These figures shows the insecurity that the world is currently facing in terms of water-energy and food. Future projections do not show an improved scenario, as population of the world is expected to increase to almost 10bn by 2050 (DESA 2015, 1) with 60% of more food needed to be cultivated in order to meet

¹ Defined by FAO as No Food for a day or more

the growing demand; energy requirement is also projected to increase by 50% by 2035 and use of water for irrigation will require 10% increase utilization than current usage (Swatuk and Cash 2018, 2). These projections, coupled with the impact of climate change, show increasing pressure on and challenge for natural resource use of water-energy-agriculture for sustainable development in the future.

Various theoretical models are been developed to deal with these challenges in an integrated manner. A nexus rather than a silo approach is being advocated in resolving this conundrum as it helps in the formulation of policies and practices which are integrated (Swatuk and Cash 2018, 2). According to Stern and Ojendal “A nexus can be understood as a network of connections between disparate ideas, processes or objects; alluding to a nexus implies an infinite number of possible linkages and relations” (Stern and Ojendal 2010, 11). The Water-Energy-Food nexus is a method which studies the interlinkages between water, energy and food, as well as considering the synergies, trade-offs and potential conflict that may arise from the management of these resources (Reinhard, Verhagen, Wolters and Ruben 2017, 5). At the 2011 World Economic Forum, the Water-Food-Energy-Climate (WFEC) nexus approach was promoted to providing solutions to the natural resource problems that the World will face in the nearest future by developing coherent policies via a multi-stakeholder platform to assist in generating the necessary consensus and the required expertise alongside the implementation capabilities needed in solving the WFEC challenge (Waughray 2011, 13). The Bonn 2011 conference advocated the Water-Energy and Food (WEF) nexus as a policy solution to dealing with the future resource challenges as it helps to reduce externalities and improve efficiency across sectors while also promoting a change to a green economy (Hoff 2011, 4, 5, and 7). The WEF nexus reveals the multifaceted and the interconnectedness of global natural resources (FAO 2014, 3). While this approach is applauded based on its key strengths of it been able to transcend the water only management approach, ability to integrate the key three resources needed by humanity and also the possibility of forming a public –private partnership solution (Giupponi and Gain 2017, 1882). It did not however take into consideration the concept of livelihood which is needed for sustainable development (Biggs et al 2015, 390).

The WEF nexus emphasizes on the macro level of policy with less attention given to the complexity at the micro level which impacts on individual livelihood (Biggs et al 2015, 390-1). At the 1992 UN Conference on Environment and Development, sustainable livelihoods was identified as a means of connecting the socioeconomic and environmental concerns (Brocklesby and Fisher 2003, 185-6). The usefulness of the sustainable livelihood approach was also advocated by UNDP as a means of analysing the interconnectedness between environmental actions and its impact on social change and poverty (UNDP 2017, 1).

The purpose of this research is to provide key insights between the physical and social sciences by recommending the inclusion of sustainable livelihood into the water energy food nexus based on empirical study of a rural community in Taiwan. The study applied the Sustainable Livelihood Framework of the Department for International Development (DFID) on the impact of the construction of regional reservoir on rural economy of Pinglin District in Taiwan. The construction of large scale water dams contributes positively to the water energy food nexus but also often times affects livelihood and has adverse social and environmental implications (FAO 2014, 2; Matthews and McCartney 2018, 58). The inclusion of SL into WEF nexus will help address its limitations by providing solutions to the natural resource challenges that faces the world.

This study canvasses that for the water energy food nexus to effectively address the natural resource challenge of the future there is the need for the introduction of sustainable livelihood into the nexus as it helps to connect the socioeconomic and environmental dimensions of development. The paper proceeds further with the outline of the theoretical framework of the sustainable livelihood approach (SLA), followed consecutively by the contextual background in Pinglin, the research methodology, findings from the study, discussion of findings and finally the conclusion.

Sustainable Livelihood Approach SLA

Livelihood comprises the capabilities, assets and activities required for means of living and this is sustainable when it can cope with and recover from stress and shocks, sustain or improve its capabilities and provide opportunity for the next generation (Chambers and Conway 1991, 6). The SLA of DFID focuses on people instead of the resources they utilized or the government in its developmental strategies. It takes a holistic approach in analysing the constraints and opportunities that are available to people irrespective of which dimension (i.e. in which sector, geographical space or level, from the local through to the international) it happens. By so doing, it is able to have an insight into how people's livelihoods are determined based on various influencing factors and how these can be adjusted in enhancing their livelihood outcomes. The livelihood approach emphasizes the need for more collaboration of macro policies and planning to be informed by knowledge gained at the local level, as the exclusion of rural areas as often led to underestimation of the impact of developmental activities (DFID 1999,1.3). The use of a framework helps in analysing the main factors that affects people's sustainable livelihood and the multiple relationship between these factors in a developmental project (DFID 1999, 2.1). Its effectiveness as an analytical tool is useful in investigating the interconnectedness between environmental actions and social change (UNDP 2017, 1).

The sustainability livelihood framework summarizes the main components of livelihood assets and strategies which are used by individuals and communities in order to survive in face of shocks and crises as depicted in Figure 1. Livelihood is sustainable if natural resources are conserved for future generations, baseline economic welfare is achieved and maintained, social exclusion is minimized and institutions are able to perform their activities over a long period (DFID 1999, 1.4 and 2.1).

The livelihood framework recognizes five capitals- human, natural, social, physical and financial –which are necessary to attain progressive livelihood outcomes and no one capital is adequate to produce the various different livelihood outcomes that people desire (DFID 1999, 2.3).

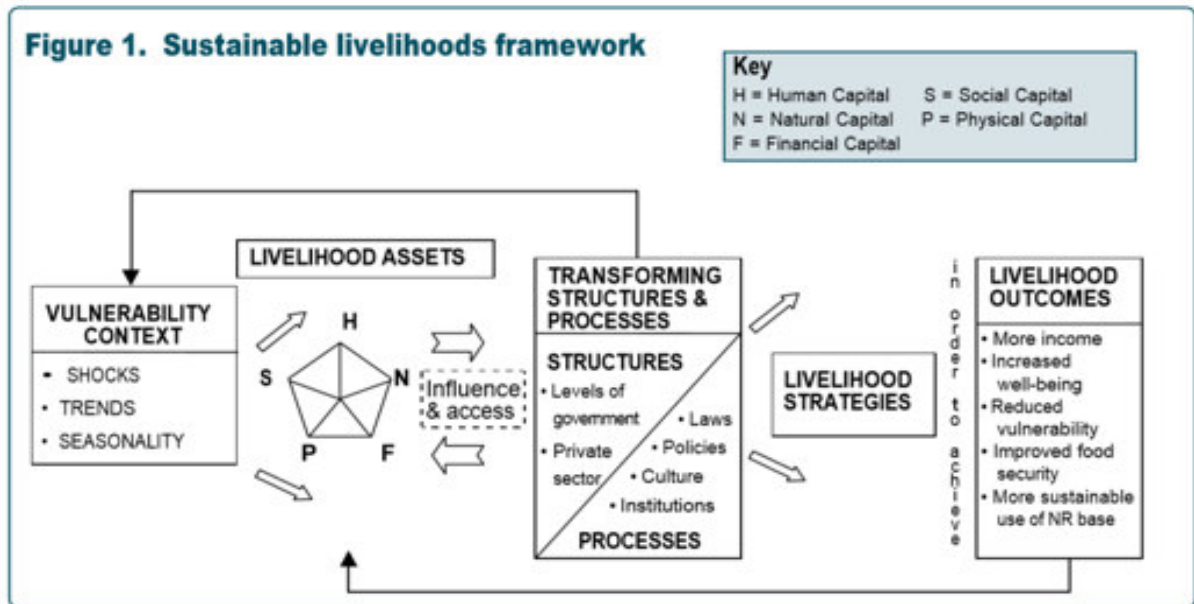


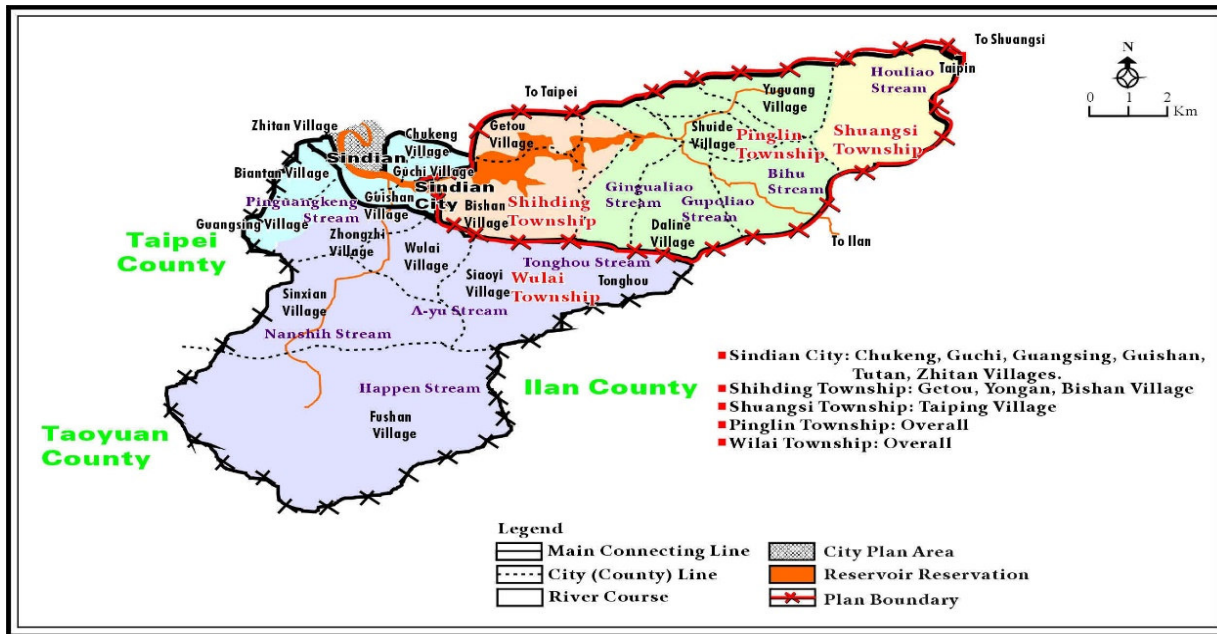
Figure 1: The DFID Sustainable Livelihood Framework 1999, 2.1

While it is noted that livelihood approaches are often absent in environmental focused projects (UNDP 2017, 18), the use of the SLF in analysing the impact of the construction of water reservoir on economic agents livelihood in Pinglin will reduce the gap in literature on the interlinkages between the WEF nexus and sustainable livelihood.

Contextual Background.

Pinglin District in Taiwan, surrounded by mountains and hills is located on the southeast of the New Taipei City. Its geographical size is about 173.83 square kilometer town, making it the third largest district in the New Taipei City Municipal Government comprising of 29 Districts (Lin, 2012. 90 and 92). The terrain of the area which is between 150meters and 1200 meters above sea level alongside its abundant natural water resource flowing from upper segment of the Beishi River makes it conducive for tea cultivation and as catchment area for the construction of water reservoir (Pinglin District Office [PDO], 107 years annual statistics, 3). About 80% of the local economy activities are centered on the growing of tea and tea marketing (PDO, 107 years annual statistics, III).

The rapid economic development coupled with population expansion in Taiwan and most especially in Taipei City in the 1970s lead to the construction of regional reservoirs in different part of the country to mitigate the then water scarcity as the supply system was not able to meet up the growing demand (Chou, Lee and Yeh 2013, 666). The closeness of Pinglin District to Taipei City coupled with its abundant water resource from the Beishi River and topographic features lead to its selection as one of the catchment areas for the construction of Feitsui Reservoir (Chiang 2015, 3-4). Figure 2 shows that the entire land of Pinglin falls into the conservation zone for the Feitsui Reservoir construction.



Taipei Water Source Domain

Figure 2: Map of Water Catchment Zone.
Retrieved from <https://www.wratb.gov.tw/media/2714/bscope.jpg>

According to Taipei Feitsui Reservoir Administration (TFRA) the reservoir with watershed area of 303kms was constructed between 1979 and 1987. It not only supplies close to 3.35 million cubic meters of water to residents of greater Taipei but also serves as power generation and flood mitigation (TFRA Promotional Material). Since the entire land of Pinglin District fell under the watershed area for the construction of the reservoir strict laws and regulations were put in place to preserve the water quality and quantity (PDO, 107 years annual statistics, 2).

Part of the law prevents the construction of building if the natural slope of the area is greater than 30%, table 1 shows that 80% of land is not available for construction so as to enhance further development of the District. The strict restrictions on housing renovation have also made it expensive for the residents to embark on such activity as houses are only left to waste instead of renovating (PDO, 107 years annual statistics, 2 and 7). The imposition of these laws and regulations has not only hindered economic activities such as industrial expansion and land utilization for the District but it has also affected the living standards of the people (PDO, 107 years annual statistics, 2 and 7; Chang 2016, 17).

Table 1. Distribution of Land Type in Pinglin

Slope Distribution		Percentage of Area
More than 45%		60%
45-30%		20%
30-20%		14%
20% or Less		6%

Source: Pinglin District 107 years Annual Account

These laws and regulations aside from affecting economic activities for the District has also affected its population growth. The population size has not grown over 7000 people over the years with population growth of about zero percent as younger generations in the District are migrating to the urban cities due to the various restrictions on industrial expansion and commercial activities that have stalled employment opportunities (PDO, 107 years annual statistics, 6 & 7).

In order to compensate for the usage of its natural resource, Pinglin District is been compensated annually via a water refund policy distribution from the Taipei City Government. Table 2 shows the distribution of annual water refund based on available data from 2011 to 2017 which are classified under the following; residential subsidies, agricultural promotion, water resource conservation, tourism promotion, and local activities (Chiang, Wang and Huang 2018, 147).

Table 2 – Distribution of Annual Water Resource Refund (2011-2017)

Classification of Distribution	2011	2012	2013	2014	2015	2016	2017
	NT\$'000	NT\$'000	NT\$'000	NT\$'000	NT\$'000	NT\$'000	NT\$'000
Residential Subsidy	42,450	42,450	43,000	52,750	52,730	49,000	48,050
Local Activities	7,900	8,000	7,300	5,830	4,770	6,860	5,750
Tourism Promotion	3,500	3,400	3,500	8,000	25,500	16,200	2,240
Water Resource Protection	4,770	6,770	9,000	5,500	3,200	11,150	12,260
Agricultural Promotion	6,500	6,500	6,500	4,500	4,150	2,700	3,700
Total	65,120	67,120	69,300	76,580	90,350	85,910	72,000

Source from Pinglin District Office cited in Chiang, Wang and Huang, 2018. Page 147

A further breakdown of the classification for residential subsidy includes promotion of social welfare in terms of national health and accidental insurance among others; local activities consist of local transactional connections and communication among others; tourism promotion consist of promotions and trainings; agricultural promotion entails promotion of agricultural goods, subsidies on pesticide for Tea Farmers and various coordination of tea competition within and outside Pinglin among others (Chiang 2015,13; PDO Sponsorship Guidelines 2019 Report, 5, 17 & 24). These various subsidies are meant to compensate Pinglin for the use of its water resources which have led to the introduction of the Water Protection Laws and Regulations in the District.

The above contextual background shows the current prevailing restrictions in Pinglin rural economy and this research aims to explore the implications of the construction of the water reservoir on the sustainable livelihood of the economic agents in the District using the DFID SLF.

Research Methodology

The study was conducted in Pinglin District using mixed method research approach as it has a better capacity to answer complex research phenomena than a qualitative or quantitative research method in isolation thereby giving a more a complete understanding of the research question under study (Lund 2012, 157). Semi structured interview and Survey were the main research tools used for data collection across economic agents such as entrepreneurs and government workers (Nelson 2009, 5) in the study area between the period of June and July 2019. Tea farming and its related value chain development (VCD) controls about 80% of the economic activity in the study area (PDO, 107 Annual Report, page 7). In this regard five category of economic agents as shown in the figure 3 below were surveyed and interviewed.

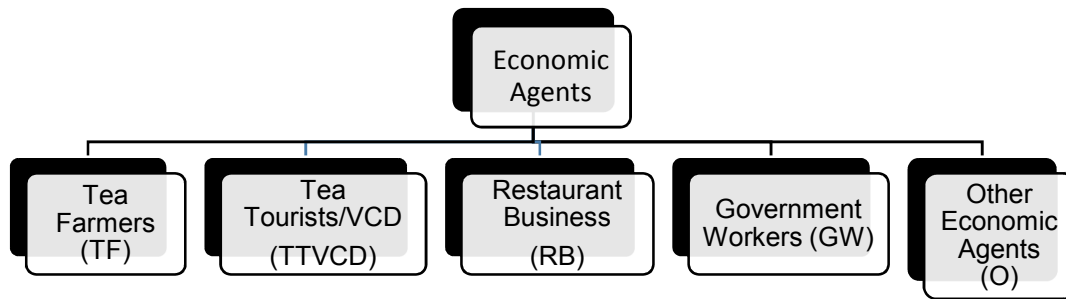


Figure3 Categories of Economic Agents Surveyed

Key Informant Interviews

Six key informant interviews were conducted using semi structured open ended questions that were developed using the sustainable livelihood framework. Key informants were selected by National Taiwan University (NTU) based on informant position within the community and who are able to give a deeper information on the phenomena of study (Marshall 1996, 92). The Interviewees were conducted mostly in Taiwanese using Research Assistant from NTU, these gave their candid opinion and shed more insight on the contextual situation in Pinglin. The Interview session lasted on average one hour allowing for deeper exploration of phenomenon and information gathered in most cases were unanimous across all spectrum of questions.

Questionnaire Interviews

In conducting the survey, primary data was collected via a face-to-face questionnaire interviews which contained 11 sections and 42 questions across the SLF. Economic agents who had shops in the business areas of Pinglin District comprising of Pinglin Old Street, Pinglin Road, Shuide Industry Road, Pingshuang Road, Beiyi Highway (Section 8) and Da-Lin were surveyed with the help of Research Assistant from NTU.

Framework of Survey and Semi Structure Interview Questions

The SLF allowed for a thorough development of questions in assessing how livelihoods have been affected along the below components since the construction of Feitsui Reservoir (FR) and the introduction of the various Laws to control water quality;

The Vulnerability Context

The vulnerability context in the DFID SLF is the external environment in which people exist and over which they have no influence over. This factor is crucial on people’s livelihood as it directly affects the assets that people have and the choices available in order to survive (DFID 1999, 2.2). In the context of the study, economic agents were asked if their businesses have been able to compete with other businesses outside of Pinglin and if employment opportunities have been on the rise after the construction of FR and introduction of the various laws.

Human Capital

In the SLF this represents the skills, experience, ability to work and good health that when combined enables people to engage in various livelihood strategies thereby realizing own livelihoods objectives (DFID 1999, 2.3.1). Part of the component of the water resource refund to Pinglin is for Agricultural and Tourism promotion which is to improve skills as well as social welfare that takes care of health insurance (Chiang 2015, 13; PDO Sponsorship Guidelines 2019 Report, 5, 17 & 24). Questions were asked if the annual distribution of the water resource refund have improved the business skills and health status of economic agents.

Social Capital

According to DFID this refers to the social resources, which people depend upon on when seeking their livelihoods objectives. It includes the networks, association, local authorities etc. that people can draw upon in influencing structures and processes (DFID 1999, 2.3.2). Another component of the Water Resource Fund is for the promotion of Business and Tea Competition within and outside Pinglin and also local activities that enhances transactional connections and communication for economic agents within Pinglin (Chiang 2015, 13; PDO Sponsorship Guidelines 2019 Report, 5, 17 & 24). In this context economic agents were asked if the construction of the FR have increased their business connections within and outside Pinglin.

Natural Capital

Within the SLF this connotes the stocks of assets such as land, forest, property etc. which are used as inputs for creating livelihood. This capital is very close to the vulnerability context within the framework especially on those that depend on natural resources for livelihood (DFID 1999, 2.3.3). In Pinglin land is either privately or government own and there are various restrictions based on the water protection laws and regulation on how natural capital can be used. Therefore economic agents were asked the type of ownership structure of their land/farm/property of business and if these can be used for multiple uses to enhance livelihood outcomes. Also question on the adequacy of the water resource refund in compensating for lost business opportunities of economic agents was also asked.

Physical Capital

Physical Capital refers to the basic infrastructure and production inputs required to assist livelihoods and lack of this further entrenches poverty (DFID 1999, 2.3.4). In the context of sustainable livelihood questions were asked if the construction of the water reservoir has made Pipe borne water available for home use and other uses as such irrigation of farms and if this was affordable.

Financial Capital

This denotes the financial resources such as stocks and regular inflow of money which people use to realize their objectives regarding livelihoods within the SLF (DFID 1999, 2.3.5). The distribution of the annual water resource refund is expected to enhance the financial capital of economic players in Pinglin. In this regard, economic agents were asked if their income have been increasing and cost of doing business have been decreasing due to the annual water refund remittance. Question was also asked if the refund is sufficient in taking care of their total annual medical bills. These are to help augment financial capital thereby enhancing livelihood outcomes.

Transforming Structures and Processes (TSP)

TSP within the SLF are the institutions, organizations, policies and legislations that help determine livelihoods. They define the access that people have to various types of capital and livelihood strategies. Making TSP work for the poor has always been a common challenge in the developmental space (DFID 1999, 2.4 and 2.4.1). Along this line, economic agents were asked if their total interest were considered in the construction of the FR cum introduction of the Laws and if they thought that these Laws can be amended to accommodate further development in the community. They were also asked if their property can be converted into other uses within the current laws.

Livelihood Strategies

Livelihood Strategies in the SLF is the range and combination of choices and opportunities that people have so as to survive the shocks and stresses of the vulnerability context (DFID 1999, 2.5). In this context economic agents were asked if they have other businesses aside the current one, investments such savings and pensions and if they receive financial support.

Livelihood Outcomes.

Livelihood Outcomes are the accomplishments of Livelihood Strategies that people seek to attain which must be sustainable. This could be inform of increased income, increased well-being, etc. (DFID 1999, 2.6). In light of this, economic agents were asked to rate how the construction of the FR has increased their income, improved well-being and social inclusion in addition to reduced vulnerability to shock.

Data Analysis

Field data from the questionnaire were entered into a database using Microsoft excel tool which helped to summarize the results in tables across economic agents for better comparison. The use of tables serves as a useful method of organizing information as it helps to reveal the differences between stakeholders (Ashley and Hussein 2000, 39). Data from the semi-structured interview were transcribed from Taiwanese into English and coded across key themes of the SLF which was used in synthesizing the result from the quantitative data. The use of coding helped the Researcher in evaluating and organizing qualitative data along relevant themes when transcribing interviews (Cope 2010, 441).

Results

The findings from the survey and semi-structured interview focuses on the usage of DFID SLF in analysing how the building of Feitsui Reservoir which supplies water and electricity to Taipei City have affected the sustainable livelihood of economic agents in Pinglin.

Table 3 shows that 108 respondents were surveyed with 55 females and 53 males with the largest group of economic agents coming from Tea Farmers constituting 44% of the total respondents. Most Economic Agents had 20 years and above experience in their business and as such were able to give insightful comparison on what the operating business environment were before and after the construction of the reservoir. The interviewees from semi-structured interviews comprises of five males and one female from different spectrum economic activities in Pinglin.

Table 3: Demographics of Respondents

Table 3 - Demographics of Respondents Survey (n= 108)						
	TF	TTVCD	RB	GW	O	Total
Male Respondents	30	5	6	2	10	53
Female Respondents	17	22	3	3	10	55
Mode of Age Bracket (Years)	55-64	55-64	35-44	55-64 & 25-34	65 & above	
Mode of years of been in Business	20 & above	20 & above	1-5	11-15 & 1-5	20 & above	
Mode of Educational Level	High School	High School	University	High School & University	Primary School	
						108

The responses of economic agents to the questions asked using the SLF are presented below.

The Vulnerability Context

In the context of vulnerability, 55 of the respondents were of the view that the construction of FR and the introduction of the laws has hindered the ability of their businesses to compete outside of Pinglin. 53 respondents were of the opinion that their businesses have been able to compete outside of Pinglin based on Table 4A. 64% of the total number of Tea Farmers (TF) surveyed opined that their businesses have not been able to compete while 70% of the Tea Tourist and Value Chain Development (TTVCD) economic agents had a contrary view. Almost all of the respondents agreed to the fact that employment opportunities in Pinglin have either been static or decreasing based on Table 4B.

Table 4A - Ability to compete with same type of Business outside of Pinglin (n= 108)						
Vulnerability Context Responses	TF	TTVCD	RB	GW	O	Total
My business cannot compete	30	8	6	2	9	55
My business can compete	17	19	3	3	11	53
Total	47	27	9	5	20	108

Table 4B - Rise in Employment /Job Opportunities in Pinglin (n= 108)						
Vulnerability Context Responses	TF	TTVCD	RB	GW	O	Total
Static & Decreasing	47	26	9	5	20	107
Increasing		1				1
Total	47	27	9	5	20	108

All of the interviewees alluded to the fact that the construction of the reservoir, which led to the introduction of various laws, is good for the preservation of water quality, but not for development of the District.

Human Capital

Almost all the economic agents were of the view that the water resource compensation for using their natural resources has had no impact in improving their business skills. In the context of improvement in health status, 82% of the respondents opined that the health insurance from the compensation have no impact on their health status as shown in Table 5A and 5B.

Table 5A - Impact of Water Resource Refund on Improved Business Skills/Knowledge (n= 108)						
Human Capital	TF	TTVCD	RB	GW	O	Total
No Impact	45	27	9	4	18	103
Positive Impact	2	0	0	1	2	5
Total	47	27	9	5	20	108

Table 5B - Impact of Water Resource Refund on Health Status (n= 108)						
Human Capital	TF	TTVCD	RB	GW	O	Total
No Impact	41	19	8	5	16	89
Positive Impact	6	8	1	0	4	19
Total	47	27	9	5	20	108

All of the interviewees also conceded to the fact the refund has had no impact on business skills and health insurance, they were all of the view that the amount for health insurance is too small as locals still had to pay substantial part of the medical bills.

Social Capital

The social capital dimension of the survey indicated that the compensation for the use of Pinglin natural resource have not helped in business connections both within and outside of District. Table 6A shows that 52% economic agents surveyed were of the view that the refund has had no impact. Table 6B shows the water refund has not helped to improve their social capital as 67% of the respondents were of the view that this has not improved their business connections outside of Pinglin.

Table 6A - Impact of Water Resource Refund on Improved Business Connections within Pinglin (n=108)						
Social Capital	TF	TTVCD	RB	GW	O	Total
No Impact	24	12	6	2	12	56
Negative Impact	11	5	2	3	5	26
Positive Impact	12	10	1	0	3	26
Total	47	27	9	5	20	108

Table 6B - Impact of Water Resource Refund on Improved Business Connections outside Pinglin (n= 108)						
Social Capital	TF	TTVCD	RB	GW	O	Total
No Impact	35	16	7	2	12	72
Negative Impact	7	5	2	3	5	22
Positive Impact	5	6	0	0	3	14
Total	47	27	9	5	20	108

The Interviewees highlighted the fact that the District have made a lot of sacrifice for Taipei City which have neither helped in improving their social capital both within and outside of Pinglin.

Natural Capital.

The stock of capital that economic agents uses in Pinglin are mostly privately owned as 82% of the economic agents from Table 7A own their Property for creating livelihood, however 90% of the respondent claimed that they cannot use their Property for others uses due to selection of Pinglin as a catchment area based on Table 7B. Table 7C shows that the water refund has not

compensated for lost business opportunities as 92% of the economic agents confirmed its inadequacy.

Table 7A - Type of Ownership Right on Land/Farm/Business Property (n= 108)						
Natural Capital	TF	TTVCD	RB	GW	O	Total
Private Ownership	42	23	6	3	15	89
Community Ownership	1	0	0	0	0	1
Government Ownership	3	1	1	2	2	9
Rental	1	3	2	0	3	9
Total	47	27	9	5	20	108

Table 7B - Ability to Utilize Property for other Multiple Uses (n= 108)						
Natural Capital	TF	TTVCD	RB	GW	O	Total
Cannot use for other uses	44	21	7	5	20	97
Can use for other uses	3	6	2	0	0	11
Total	47	27	9	5	20	108

Table 7C - Adequacy of Water Refund to Compensate on lost Business Opportunities (n= 108)						
Natural Capital	TF	TTVCD	RB	GW	O	Total
Not Adequate	44	27	9	4	15	99
Adequate	3	0	0	1	5	9
Total	47	27	9	5	20	108

A common theme that resonates among all the interviewees is that Properties are mostly privately or government owned and that these cannot be used for other purposes other than the initial use it was registered for.

Physical Capital

In Pinglin there are two main sources of water which are pipe borne and spring water, most of the respondents attested to the availability of pipe borne water and its affordability based on Table 8A and 8B. However 62% of the respondents opined that pipe borne water is only available for home use only and not for other uses like irrigation of farm land.

Table 8A - Availability of Pipe Borne Water for Home use and other uses (n= 108)						
Physical Capital	TF	TTVCD	RB	GW	O	Total
Not Available for Home Use/Other Uses	14	2	2	1	2	21
Available for Home Use only	32	12	5	4	14	67
Available for Home Use and Other Uses	1	13	2	0	4	20
Total	47	27	9	5	20	108

Table 8B - Affordability of Pipe Borne Water (n=108)						
Physical Capital	TF	TTVCD	RB	GW	O	Total
Not Affordable	8	2	0	1	2	13
Affordable	39	25	9	4	18	95
Total	47	27	9	5	20	108

Financial Capital

The various restrictions of the water protection laws have had a negative impact on the financial capital of most Economic Agents in Pinglin. Table 9A shows that income has either been static or decreasing since the construction of the reservoir. 62% of the Tea Farmers surveyed were of the view that their income have been decreasing. Most of the respondents are of the opinion that the water refund has not reduced their cost of doing business and the introduction of the laws have restricted their ability to engage in other types of businesses based on table 9B and 9C. Table 9D shows the insufficiency of the water refund remittances in meeting up with economic agents annual medical bills as 90% of the respondents attested to this.

Table 9A - Rise in Income since the construction of Feitsui Reservoir/WPZ (n= 108)						
Financial Capital	TF	TTVCD	RB	GW	O	Total
Static	17	19	3	4	12	55
Decreasing	29	7	6	1	8	51
Increasing	1	1	0	0	0	2
Total	47	27	9	5	20	108

Table 9B - Reduction in Business Cost due to Water Refund Remittance (n= 108)						
Financial Capital	TF	TTVCD	RB	GW	O	Total
No Impact on Business Cost	43	23	8	5	18	97
Positive Impact on Business Cost	4	1	0	0	2	7
Not Aw are	0	3	1	0	0	4
Total	47	27	9	5	20	108

Table 9C - Ability to Engage in other Businesses since the introduction of WPZ (n= 108)						
Financial Capital	TF	TTVCD	RB	GW	O	Total
Not been Able	40	18	6	3	16	83
Have been Able	7	9	3	2	4	25
Total	47	27	9	5	20	108

Table 9D - Sufficiency of Water Refund Remittance for Annual Medical Bills (n= 108)						
Financial Capital	TF	TTVCD	RB	GW	O	Total
Not Sufficient	46	22	8	5	16	97
Sufficient	0	1	0	0	1	2
Not Aw are	1	4	1	0	3	9
Total	47	27	9	5	20	108

Transforming Structures and Processes

The current water protection laws seems not to be favorable to Pinglin as most of the economic agents based on Table 10A and 10B responded to the fact that their total interest were not considered in enacting these laws and as such would want these laws be amended. Also most of the respondents still maintained that they are not able to convert their property into other uses and those that think that they can are of the view that the processes are long based on Table 10C.

Table 10A - Views on If the Total Interest of Pinglin was Considered in Building the Reservoir/WPZ (n= 108)						
Structures	TF	TTVCD	RB	GW	O	Total
Total Interest was not considered	38	18	3	2	8	69
Pinglin's Interest was considered but not Total	9	9	6	3	9	36
Pinglin's Total Interest was considered	0	0	0	0	3	3
Total	47	27	9	5	20	108

Table 10B - Views on if Laws and Regulations should be Amended to Accommodate Development (n= 108)						
Structures	TF	TTVCD	RB	GW	O	Total
Laws should not be Amended	10	6	0	0	10	26
Laws should be Amended	37	21	9	5	10	82
Total	47	27	9	5	20	108

Table 10C - Ability to Convert Property into other uses Seamlessly under the Laws (n= 108)						
Processes	TF	TTVCD	RB	GW	O	Total
I cannot convert into other Uses	44	17	6	3	14	84
I can convert but Processes are long	1	7	2	0	1	11
I can convert with less Processes	2	0	0	2	0	4
I am not aware that I can convert	0	3	1	0	5	9
Total	47	27	9	5	20	108

Livelihood Strategies

The ability of economic agents in Pinglin to withstand shocks is daunting as 71% of the respondents do not have any other form of business venture aside the current business and 73% of them do not have personal investments to fall back to in time of crisis as shown in Table 11A and 11B. 60% of the economic agents surveyed have to depend on the receipt of external financial support based on Table 11C.

Table 11A - Economic Agents Ownership of other Businesses (n= 108)						
Livelihood Strategies	TF	TTVCD	RB	GW	O	Total
No other Business venture	32	21	7	4	13	77
Have other Businesses in Pinglin	6	3	2	1	1	13
Have other Businesses outside Pinglin	9	3	0	0	6	18
Total	47	27	9	5	20	108

Table 11B - Economic Agents Ownership of Investments - Savings and Pensions (n= 108)						
Livelihood Strategies	TF	TTVCD	RB	GW	O	Total
Do not have Investments	34	21	6	3	15	79
Have Investments	13	6	3	2	5	29
Total	47	27	9	5	20	108

Table 11C - Economic Agents Receipt of Financial Support (n= 108)						
Livelihood Strategies	TF	TTVCD	RB	GW	O	Total
Do not Receive Financial Support	12	15	1	4	11	43
Receives Financial Support	35	12	8	1	9	65
Total	47	27	9	5	20	108

Livelihood Outcomes

Economic Agents in Pinglin are of the view that the selection of the District as one of the catchment zone for the construction of the reservoir has had no impact on their livelihood outcomes as 94% of them were of the opinion that their income have not increased while 64% of them were of the view that this has not increased their well-being or social inclusion as shown in Table 12A and 12B.

Table 12A - Economic Agents Overall Ratings on the Construction of FT Reservoir on Livelihood Outcomes (n= 108)						
Livelihood Outcomes- Income	TF	TTVCD	RB	GW	O	Total
No Impact on Income	46	24	8	5	18	101
Increased Income	1	3	1	0	2	7
Total	47	27	9	5	20	108

Table 12B - Economic Agents Overall Ratings on the Construction of FT Reservoir on Livelihood Outcomes (n=108)						
Livelihood Outcomes-Well-being & Social Inclusion	TF	TTVCD	RB	GW	O	Total
No Impact	37	18	6	1	7	69
Increased Well-being and Social Inclusion	10	9	3	4	13	39
Total	47	27	9	5	20	108

Discussion

The study specifically set out to analyze the importance of introducing the concept of sustainable livelihood into the water energy food nexus as it helps to connect the socioeconomic and environmental dimensions of development. The findings from the study highlights how Economic Agents’ sustainable livelihoods have been affected due to the selection of its area as a catchment zone for the construction of reservoir that serves Taipei City.

The sustainability of people's livelihood as highlighted by DFID (DFID 1999, 2.4) is determined by the transforming structures and processes that exist for the people which is the case for Pinglin. The introduction of the various laws and regulations so as to preserve the water quality have made economic agents in the District to be vulnerable as most businesses are not able to compete with same type of businesses in other Districts. The District is known for the cultivation of Tea due to its rich natural resources that support its planting. As mentioned by some of the key informants, this has been a constraint on their activities as Tea Farmers are restricted on the type of equipment and pesticides that can be used for farming and also do not have access to more land to help increase production as available land belongs to the government which is mostly used for forestry. One of the interviewees alluded to the facts that the number of Tea Farmers has reduced by half between 1970s and current year of 2019 also supporting the survey outcome of declining employment opportunities. The declining employment opportunity as mentioned by in the PDO annual report (POD, 107 years annual statistics, 7) is one of the major reasons why the youths in Pinglin are migrating out of the District.

The livelihood framework recognizes that people require the combination of variety of capital to achieve sustainable livelihood (DFID 1999, 2.3). Economic Agents in Pinglin requires the combination of these livelihood assets so as to achieve their livelihood outcomes. The water refund remittance is expected to compensate the District for the usage of its natural resources (Chiang 2015, 13), however the livelihood assets of economic agents have either been static or declining since the introduction of the water laws and regulations. The human capital dimension of the livelihood assets of economic agents have not been developed by the expected technical assistance and health insurance from the water refund. Most respondents and interviewee stressed the insufficiency of the medical insurance claims in meeting their annual medical bills.

Although most properties are privately owned in Pinglin, this cannot be used for multiple uses and economic agents seeking to renovate their properties have to go through a long process and as such houses are left to waste (PDO 107 year annual statistics, 7). Farmers that are seeking to get additional hectares of land to increase production of tea are finding it difficult in getting additional land from the government. Land that is eventually rented from government can only be used in the production of Tea and have to be given back to the government upon the demise of the person. This land according to one of the key informant goes back into forest and not for farming. These restrictions have limited the expansion of the natural capital of economic agents in Pinglin.

The findings from the study shows the economic agents in Pinglin have been disadvantaged financially as income have either been static and decreasing. Tea Farmers in the District are finding it difficult in sustaining their livelihoods has most of them attested to declining income and the availability of pesticide from the agricultural promotion via the water refund have not been able to defray the cost of doing business. As mentioned by Chang (2016, 16) most farmers in Pinglin are struggling to survive and citizens in the urban centers using the water from the reservoir are unaware of this situation.

Result on physical capital reveals the availability of pipe borne water as most economic agents attested to the affordability of pipe borne water. However, most of the Tea Farmers however alluded to the availability of pipe borne water for home use only. The consensus of the interviewees is that availability of pipe borne water is based on where you are leaving in Pinglin as economic agents such as Tea Farmers that have their businesses in the mountain areas make use of spring water which is free.

On the social capital dimension, this asset has also been on static and declining both within and outside Pinglin as economic agents businesses have not been able to establish the required business connections. Also the various tea tourism promotions that is expected to increase business connections within and outside of Pinglin have not been that beneficial in this regard.

The impact of the water protection laws and regulations have not only affected the capacity of economic agents in building up their livelihood assets but have also constrained their livelihood strategies which ultimately have affected their livelihood outcomes. More than half of the economic agents surveyed do not have investments and have to rely on external financial support as a major livelihood strategy. These findings supports the result on livelihood outcomes as almost all the respondents were of the view that the construction of the reservoir have not increased their income, well-being and social inclusion. As mentioned by most of the Interviewee who have lived in the District for more than 50 years, the construction of reservoir has not only affected the sustainable livelihood of economic agents in the District but has also had a negative impact on tea cultivation for an area known for such agricultural activity.

The summary of the research findings shows the interconnectedness of water-energy-food and sustainable livelihood. As the construction of the Feitsui Reservoir which is meant for the provision of water and energy generation for people in urban Taipei City have not only affected the sustainable livelihood of economic agents in rural Pinglin but have also affected the cultivation of Tea.

Conclusion.

The natural resource challenge that the world currently faces requires a nexus approach and the WEF nexus have been advocated as fundamental for inclusive development (McNamara, Nauditt, Penedo and Ribbe 2018, 15).

The findings from the study supports the argument for the inclusion of SL into the WEF nexus as it helps to connect the socioeconomic and the environmental concerns that the world currently faces. This implies that policy makers in the bid of solving current natural resource challenges which often times operates at the macro level must endeavor in analysing how these projects affects the sustainable livelihood of all stakeholders so that no one is left behind in the developmental process.

Many of the 17 SDGs are linked to agriculture, water, energy and land use and the WEF nexus approach have been advocated as providing the solution to the trade-off or synergies for achieving these goals (McNamara, Nauditt, Penedo and Ribbe 2018, 15). The inclusion of SL into the model of the WEF nexus will effectively help policy makers to systematically analyze these trade-off and synergies so as to achieve sustainable development. The study set out to analyze how the construction of regional water reservoir have affected sustainable livelihood but also discover in the course of the research that this have also affected the cultivation of Tea in the area known for such agricultural activity. Future research would have to be conducted in analysing the extent of the impact of the construction of the reservoir on agricultural production in the area of study.

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