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Assessing direct and indirect effect of flood disaster on smallholder agriculture: A Structural Equation Modelling Approach

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Abstract
Flood impact assessment and understanding of the costs of flood disaster is critical for decision making processes towards an integrated flood risk management by the policymakers to effectively reduce flood disaster effects. Virtually, most economic analysis of flood disaster effects focuses too often on direct physical effect, neglecting the wider indirect ones, this paper, therefore aimed at assessing both the direct and indirect effect of 2014/2015 flood disaster on smallholder agriculture in Kelantan. Data were obtained from 385 affected smallholder farmers using multistage sampling technique and analyzed through the use of correlation, factor analyses and structural equation modeling (SEM) using SPSS and AMOS software. The findings showed that flood has a significant direct effect on agriculture which in turn results in wider indirect effects. The study offers valuable implications, first it could help policymakers to facilitate and improve on the flood disaster management practices to lessen/avoid future effects in the study area and finally give an insight to academicians/researchers in applying and/or improving the model while assessing the effect of flood and other natural disasters in future research.

Nomenclature and units

AGFI	Adjusted Goodness of Fit Index
CFI	Comparative Fit Index
RMSEA	Root Mean Square Error of Approximation
TLI	Tucker – Lewis Index

1. Introduction

Globally, floods are perceived to be the most occurring natural disaster causing significant economic and social damage on the livelihoods of its victims. Its effects, especially on small scale households who normally lives along the coastal areas are enormous (Edward et al., 2011). According to Osti & Nakasu (2016) flood disaster events are increasing annually in Asia and widely considered that, economically disadvantaged communities are highly vulnerable. Floods account for about 47.80% of the total number of reported disasters in the period (2005-2015) around the globe and affect agriculture sector more than all other natural hazards (FAO, 2015). The economic cost of floods on agriculture do not only consists of direct effect (losses), such as crop failures, but also a wide range of indirect effects such as food prices and shortages, loss of income, increased vulnerability etc. which are often insufficiently taken into account (Pfurtscheller & Vetter, 2015). For instance, large and long-duration floods can, by raising agricultural prices, destabilize the whole food-chain and not only local economies (OECD, 2016). According to Harvey et al. (2014); Morton (2007) and Siddiquee (2012) smallholder agriculture is used to describe rural farmers who constitute an estimated of greater percentage of (85%) farming population worldwide, and who are mostly living along the coastal wetland, river banks and primarily considered more vulnerable to floods. Hundreds of millions of people throughout the world, particularly those living in the developing countries, are threatened by floods disaster and tropical storms that could have a devastating economic consequences for agricultural production and livelihood (FAO, 2013).

Environmental degradation as a result of human activities , heavy rainfall, illegal logging and intensified land use as a result of increasing population are factors reported to aid flood disaster occurrence and its effects, (Adnan, 2010; Dassanayake, Burzel, & Oumeraci, 2015; Noratiqah Mohd Ariff, 2010; Santos & Reis, 2017; Tahir et al., 2015). Other contributory factors that aid flood disaster effect/impact also reported in the literatures include flood duration, inundation/depth and frequency of occurrence (Dutta et al., 2003; Mojtahedi, 2015).

The assessment of flood disaster effects, as a crucial and important part of decision making process and policy development in flood risk management is often side-lined or overlooked. Thus, Lindell & Prater (2003) argued that one of the vital practical lessons on any disaster impact assessment is for policy makers to know their communities economic base by identifying vulnerable community sub-units and prepare for disaster management and recovery before it re-strikes. Although different empirical studies have studied the impact/effect of natural disasters, however, there has been little discussion that both engages specific type of natural disaster assessment and with the specific community, like smallholder farmers in the literature (Morton, 2007). In addition, Kuhlmann et al. (2008) argued that, whilst various flood damage assessments exist in urban areas flood losses assessment in agricultural production of smallholder farmers who live in rural areas are frequently neglected. However, indirect effect of flood disaster are poorly understood, since direct effects are most of the time accounted for while given partial or incomplete consideration to indirect effects (Carrera et al. 2015). But studies of Brémond et al. (2013); FAO (2015); Israel & Briones (2013) and Cavallo et al. (2010) had structurally shown that flood economic effect on agriculture include both direct and indirect effects. The direct effect includes damage/losses of crops, Livestock, farm structures and damage to farmland area and soil. While the indirect effect are losses resulting from direct damages that includes disruption of business, decrease in employment, decline in wages and high food prices. However, these and other several studies had used different methodological approaches in assessing the impact of natural disasters, such as macroeconomic models that include Input-Output (IO) Model, Social Accounting Matrix (SAM) and Computable General Equilibrium (CGE) Model, most of these models tend to ignore personal losses, livelihood disruptions and other indirect impacts (Hallegatte et al. 2010; Okuyama, 2011; Okuyama et al. 2014; Rose, 2005). In addition, Daniela et al. (2017); Dunja (2016) and Pfurtscheller & Vetter, (2015) identified lack of available and/or adequate data to evaluate the effect/damage to different sectors especially smallholder agriculture in case of floods.

While a number of studies have investigated the effect of natural disasters and climate change variability on agriculture in the study area, there is lack of studies that specifically assess the direct and indirect flood disaster effect on agriculture of smallholder farmers in Kelantan state, Malaysia. Additionally, none of the studies from the literature review was found to test an empirically validated model that examines the economic effect of flood disaster on agricultural production of smallhoder farmers using a powerful multi-dimensional Structural Equation Modelling (SEM) model of analysis.

Structural Equation Modelling (SEM) is an advanced technique that combines aspects of factor analysis and regression to simultaneously to examine relationships between measurement indicators and constructs, it has the ability to estimate direct and indirect effect simultaneously which multiple regression analysis cannot do.

SEM has been regarded as an inclusive and valuable statistical method been widely applied for theoretical explorations and empirical analysis in the study of climate change variability and other environmental disciplines in recent years (Javari, 2015).

Malaysia as a very fast growing developing nation is fortunate and relatively free from various devastating natural disasters that are periodically occurring in its neighboring countries, but flood becomes the most severe and single natural disaster exacerbating its cascading negative effect especially in east coast states such Kelantan, Terengganu and Pahang in recent decades (Chan, 2015;

Islam, Kamaruddin, Ahmad, Jan, & Anuar, 2016). Malaysia had experienced many major floods years before, however the 1926 and 2014/2015 flood events were known as the most significant flood in the history of Malaysia. In which the 2014/2015 was declared as tsunami like disaster by the National Security Council (NSC). CFE-DM (2016) argued that flood constitute as much as 62.5% economic damage and/or losses (see Figure 1.3) of all natural disasters occurring in Malaysia.

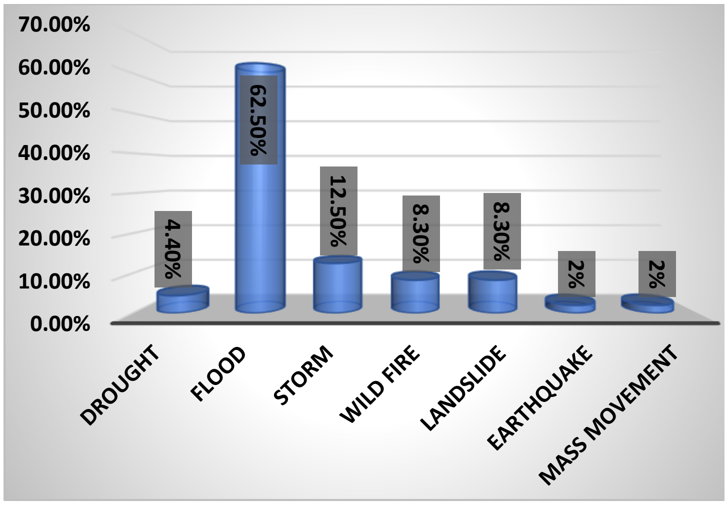

Figure Error! No text of specified style in document.. **Malaysia's Reported Losses from 1990-2014.**
Source: Malaysia Disaster Management Reference Handbook, 2016

According to Baharuddin (2007) and Jabin et al. (2015) that, agricultural sector remains one of the sectors greatly affected by flood disasters in terms of crop losses and livestock and damage to infrastructures in Malaysia.

In this paper, we examined the economic effect of 2014/2015 flood disaster in Kelantan Malaysia, by assessing both the direct and indirect effect simultaneously, in addition, it will contribute to literature by introducing a framework of direct and indirect flood disaster effect on agriculture.

2. Theoretical Framework of Analysis

Under this study variables of interest were extracted from Conceptual model of climate-impact assessment (Kates, 1985) and the framework on the impacts of natural disasters on agriculture and food security from (Israel & Briones, 2013), were extracted, modified and adopted to serve as the framework for this study. Conceptual model of climate-impact model outlines the underlying relationships and/or interactions among disaster characteristics, disaster impact on an economic activity and societal impact,

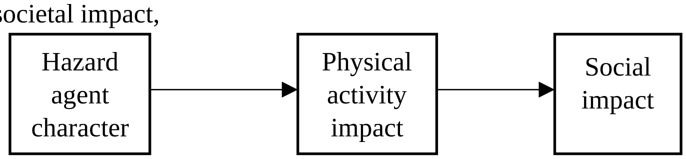

Figure 2: Conceptual model of climate-impact mode by Kates (1985)

While Israel & Briones (2013) framework highlights how flood disaster constitute flood disaster impact on agriculture constitute both direct effect which is a physical effect on agricultural production activities, and indirect effects resulting from direct damages.

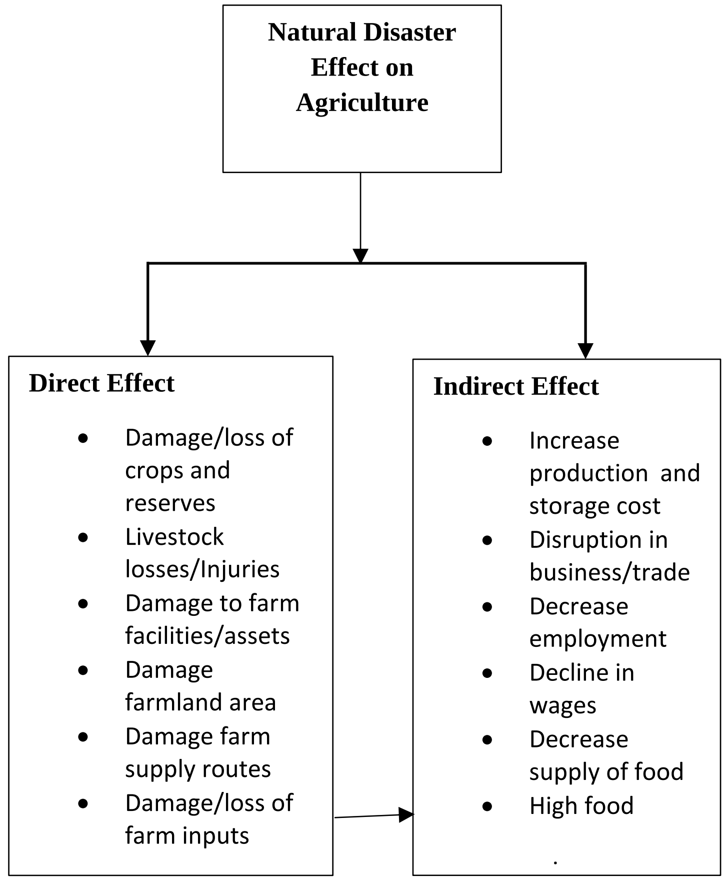

Figure 3: Framework on Natural Disaster Effect on Agriculture by Israel & Briones (2013)

3. The Conceptual Framework of the Study

Considering the objective of this study, conceptual framework for this study outlined the organization and relationship of concepts/constructs derived from the above reviewed disaster model and framework, flood disaster characteristics would serve as hazard agent characteristics; direct effect on agriculture as physical activity impact and indirect effect as social impact. Hence, the framework for this study as indicated in the Figure below consist of flood disaster characteristics (as an IV), flood direct effect on agriculture (as a mediator) and indirect effect on agriculture (as a DV).

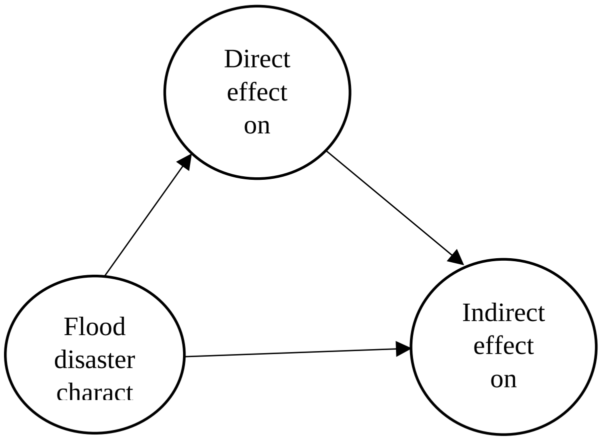

Figure 4: Conceptual Framework of the Study

4. Flood Disaster Characteristics (FDC)

These are important components used in evaluating and understanding flood disaster effects (Messner et al., 2007; Mojtahedi, 2015). They are triggering factors that that influence the extent of the damage and also define the nature and magnitude of the flood event (Dunja, 2016). Numerous literatures have identified strong relationship between flood characteristics (such as flood occurrence, duration, inundation/depth, high and persistent rain, overflowing of river, and other human activities) and its effect on on an economic activity (Adnan, 2010; Chen et al., 2016; Dutta et al., 2003; Messner et al., 2007b; Osti & Nakasu, 2016; Paul & Mahmood, 2016). According to Penning-rowsell et al. (2005) increased damages/losses are as a result of long duration of floods. Messner et al., (2007) argued that inundation depth is the most frequently used parameter in the analysis of flood disaster effect followed by flood duration. Understanding these physical characeristics of flood disaster is vital in evaluating their influence on damages/losses incurred, helps in reducing their impact and improving flood disaster response (Berkman et al. 2015; Paul, 2011).

5. Direct Effect on Agriculture (DEA)

Several literature have repoerted direct effect of flood disaster on agriculture as direct physical damage on different categories of agricultural production activities. Scholars such as (Brémond et al., 2013; D. C. Israel & Briones, 2013; Lindell & Prater, 2003; Posthumus et al., 2009) had reported direct effect of flood on agriculture as damage/losses of crops, decrease in yield and quality of crops; damage to agricultural lands, livestock losses and damage to farm assets/infrastructures. FAO (2015) outlined direct flood disaster effect on agriculture as damage to crops, seed stocks, livestock mortality, damage to agricultural infrastructures and damage to forest that support agriculture. Merz et al. (2010) argued that flood direct effect includes, erosion of agricultural soil, destruction of harvest and damage to livestock. Dunja (2016) and Torrente (2012) stated that, damage to crops, loss of livestock, damage/loss of livestock products, damage to farm building, soil, machinery, stored products and infrastructures are important direct flood disaster effect on agriculture.

However, the literature mention above and other previous research has shown that there is strong positive relationship between flood disaster characterictics and direct effect on agriculture. (Alam et al., 2016; Brémond et al., 2013; Dutta et al., 2003; Lindell & Prater, 2003; Messner et al., 2007)

6. Indirect Effect on Agriculture (IEA)

Acoording to FAO, (2015) and Pfurtscheller & Vetter, (2015) indirect effect on agriculture consists of decrease in wages, increase in food prices, business disruptions and decrease in revenue. In addition Brémond et al. (2013) and Meyer et al. (2013) examined and reported indirect effect of flood disaster on agriculture as disruption of farm input supplies and econmic activities. Others contend that indirect effects include, reduced farm productivity, increased cost of production and storage, decrease supply of food, high market prices, damage roads and markets and increase in unemployment (Dunja, 2016; Israel and Briones, 2013a; Alam et al., 2016; Merz et al., 2010).

Based on the above construct/ variable, the study come up with the following hypothesis

H1: There is no positive and significant relationship with between FDC DEA and IEA

H2: FDC has no significant and positive effect on IEA

H3: There is no mediating relationship between DEA, FDC and IEA

7. Study Area

The study area is Kelantan State of Peninsular Malaysia which has a total area of 15,099 km2 (5,830 Sq. mi). The major agricultural activities are mainly the cultivation of paddy rice, rubber, oil palm and tobacco. Fishing and livestock farming are also important occupations found in this area. However about 50% of the whole study area is threatened by floods (Jiang et al. 2009) which results in huge economic losses every year it occurred. Due to the influence of strong northeast monsoons, flood disasters happen regularly from October to the following February which is marked by heavy precipitation. Annual precipitation over the area varies between 0 mm to 200 mm in the dry season to 3000 mm in the wet or monsoon season (DID, 2006).

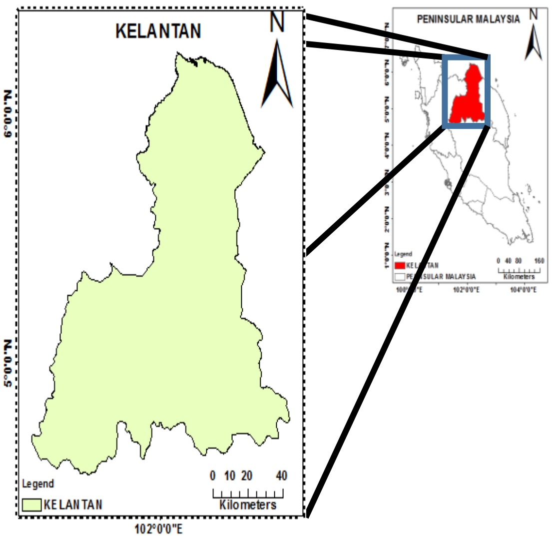

Figure 5. Map of Kelantan State

8. Sampling Methods

Multistage sampling technique which ensure that all the target smallholder farmers have an equal chance of being selected for the study was used. 424 questionnaires with clear and answerable questions based on the previous literatures were distributed disproportionately among the respondents in all the sampled districts. However only 385 questionnaires were found to be valid for the analysis, and the remaining 39 questionnaires were dropped as a result of the problem of uncompleted questionnaires and missing data. The returned response rate of the questionnaires was 90.80%. Therefore a sample 385 respondents was found to be adequate for this study as argued by Israel G. D. (2008) that a sample size is considered as good and adequate when it ranges between 200 and 500.

9. Data Analysis

Data analysis for this research was carried out using statistical tools such as SPSS and AMOS. First factor analysis was carried out (EFA and CFA) to explore and confirm factors that can measure flood disaster characteristics, direct and indirect effect of flood on agriculture. Since variables/items contained in this study were adopted and modified from previous literatures of different locations, hence, it will be of great importance to have variables placed into meaningful categories as suggested by Yong and Pearce (2013). This was followed by examining the correlation among the main variables of the study (FDC, DEA and IEA). Finally structural equation modelling approach was used to test the causal links specified in the theoretical model of the study.

10. Results and Discussion

10.1 Results of Correlation Analysis

Prior to SEM analysis, correlation among the variables of the study were analyzed. As shown in n Table 1 below, the findings of the correlation matrix indicated that the predictor variable which is flood disaster characteristics (FDC) has significant and positive relationship with the direct and indirect effect on agriculture (FDC ↔ DEA, R = .393 p = 0.000); (FDC ↔ IEA, R = .262 p = 0.000) however, DEA further has significant and positive relationship with indirect effect on agriculture (DEA↔IEA, R = .520 p = 0.000), thus H1 is supported. This implies that the more the increase in FDCs the more direct damages and losses to agricultural production activities and consequently the more indirect effects in terms of low food supply, increase in food prices, low income, wages and business disruptions.

Table 1: Correlation Coefficient Matrix of the variables

Construct/Variable		FDC	DEA	IEA	Mean	SD
FDC	Pearson Correlation	1			19.21	4.525
	Sig. (2-tailed)					
DEA	Pearson Correlation	.393**	1		23.36	6.883
	Sig. (2-tailed)	.000				
IEA	Pearson Correlation	.262**	.520**	1	18.97	4.758
	Sig. (2-tailed)	.000	.000			

**. Correlation is significant at the 0.01 level (2-tailed).

FDC: Flood disaster characteristics; DEA: Direct effect on agriculture and IEA: Indirect effect on agriculture.

10.2 Factor Analysis Result.

When majority of the items and dimensions of a study had been reported from various literatures, it would be of great importance to explore, confirm and place variables into supposed categories (Yong and Pearce, 2013). Therefore, EFA was used to uncover the underlying structure of a relatively large set of items to provide a factor whose variables has strong correlations, while CFA is used to verify the relationship between factor structure of a set of observed variables and underlying latent constructs exists (Hair et al., 2014; Robert Ho, 2006). After deletion of items that did not meet the requirement, the EFA results showed three (3) factor solutions with eigenvalues greater than 1.0 which is in line with Kaiser's criterion, the total variance explained was 61.690%, The KMO that measures the adequacy of the sample size is 0.881 which is excellent, the Cronbach alpha in all the constructs were found to be more than 0.70 indicating that, there is higher internal consistency of the measured variables as shown in Table 2 below.

Table 2: Factor Analysis Result (EFA)

Variables/Items		Factor Loadings			Reliability (Cronbach alpha)
Direct effect on Agriculture (DEA)		**F1**	**F2**	**F3**	
DEA2	Destruction of stored farm inputs	.912			.883
DEA4	Damage/loss of farm infrastructures	.878			
DEA5	experienced crop damage/loss as a result of flood	.782			
DEA6	The farmland area and soil are affected as a result of flood	.697			
DEA3	The stored crops were damage/lost due to flood disaster	.694			
DEA7	The farm machinery and equipment were damaged/lost due to flood disaster	.593			
Flood Disaster Characteristics (FDC)					
FDC1	Frequent occurrence of flood had negatively impacted on my farming activities		.795		.870
FDC4	The flood that affected my farming activities was caused as a result of high rainfall and overflowing of river		.775		
FDC5	Long duration of flood in my area has affected my farming activities		.768		
FDC2	High flood depth had significantly affected my farming activities		.750		
FDC3	The flood that affected my farming activities was caused as a result of human activities		.716		
Indirect effect on Agriculture (IEA)					
IEA3	Damage of roads and markets as a result of flood disaster			.945	.864
IEA4	Decrease in food supply and high market prices as a result of flood disaster			.885	
IEA2	Harvest failure due to flood reduce my income			.566	

Pooled CFA which is more efficient and reliable as argued by (Zainudin, 2015) was conducted using the three major constructs (IVs and DV) in order to test for the convergent validity (AVE) and construct reliability (CR) of the measurement model.

However, model fit was also determined by considering the following indices. According to Bahaman (2016) and Hair et al. (2014) that if at least one index from each category of fits Absolute fit (Chi-Square >0.05, RMSEA < 0.08 and GFI >0.9); Incremental fit (AGFI, CFI, TLI and IFI all > 0.9) and Parsimonious Fit (Chisq/df < 5.0) the model is considered to have an acceptable fit to the data.

The results indicated that almost all the recommended cut-off points of the fit indices of all the categories were achieved, thus the model of this study was found to be fit. Relative Chi-sq = 3.759, GFI = 0.903, CFI = 0.939, IFI = 0.939, NFI = 0.919, TLI = 0.924, as shown in the Figure 6 below.

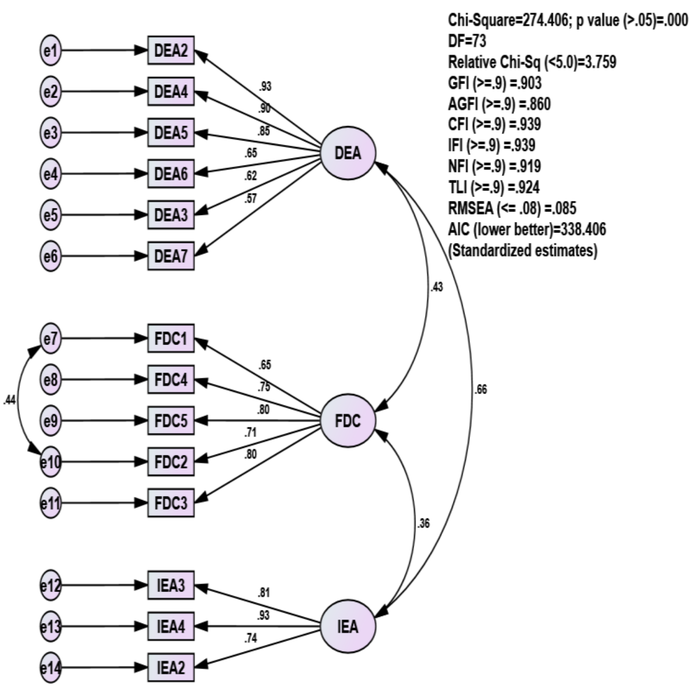

Figure 6: A path diagram indicating pooled CFA (measurement model)

With regards to validity and reliability of the model, factor loadings, Average Variance Extracted (AVE), Construct Reliability (CR), and discriminant validity were all determined. The result shows that all the factor loading estimates of each individual items were within the recommended range of >0.5. The (AVE) which measures the convergent validity of a construct also achieved above the required level of > 0.5 in all the constructs, in addition construct reliability which measure reliability and internal consistency of measured variables representing a construct (Hair et al., 2010) achieved the required level of > 0.6 as indicated in Table 3 below.

Table 3. Summary of Pooled CFA Results

Construct	Items	Factor Loading	CR (Above 0.6)	AVE (Above 0.5)
Direct effect on Agriculture	**DEA2**	**0.928**	**0.89**	**0.59**
	DEA4	**0.898**		
	DEA5	**0.851**		
	DEA6	**0.653**		
	DEA3	**0.62**		
	DEA7	**0.567**		
Flood Disaster Characteristics	**FDC1**	**0.65**	**0.86**	**0.55**
	FDC4	**0.755**		
	FDC5	**0.798**		
	FDC2	**0.711**		
	FDC3	**0.798**		
Indirect effect on Agriculture	**IEA3**	**0.813**	**0.87**	**0.69**
	IEA4	**0.927**		
	IEA2	**0.744**		

However, the test of discriminant validity showed that, the constructs which are supposed not to be related are in fact not related, and it was achieved as indicated in the Table below where the diagonal values in bold (square roots of AVE) are greater than the values in its row and column (Table 4 below) as argued by (Zainudin, 2015).

Table 4: Summary for the Constructs Discriminant Validity

Construct	FDC	DEA	IEA
FDC	**0.745**		
DEA	**0.425**	**0.766**	
IEA	**0.358**	**0.656**	**0.831**

10.3 Results of the Structural Equation Modelling (SEM)

In this study structural model was evaluated by testing the causal links specified in the theoretical model so that the interrelationships among the latent constructs can be analysed simultaneously, as argued by Hair et al. (2010) and Ho (2006) thereby identifying the contribution of the individual predictors to the dependent variable. Hence, the magnitude of the variables were analysed using Beta, critical ratio (CR), P-value and variance explained (R^2 value). Although the Goodness of fit indices, factor loadings as requirement for model fit are similar to that of pooled CFA (measurement model).

However the mediation effect was determined using Multi Model Analysis (MMA). The analysis started by assessing direct relationship between flood disaster characteristics (FDC) and the flood indirect effect on agriculture (IEA) as shown in Figure 7 and Table 5 below.

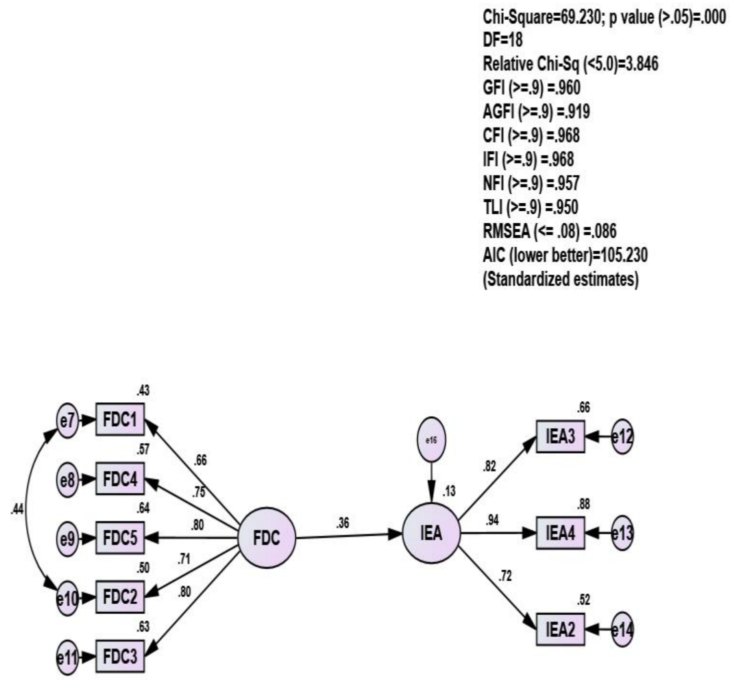

Figure 7: Path Diagram Showing Direct Effect of FDC on IEA

Table 5: Regression Weights for Direct Model

Hypothesized Relationship	Unstandardized β	S.E.	Standardized β	C.R.	P
IEA<---FDC	.529	.091	.355	5.826	***

In the direct model above the standardized coefficient was found to be significant, indicating that flood disaster characteristic contributed significantly to the direct effects such as shortage of food supply and high market prices (β = 0.355, CR = 5.826 and P < 0.000), hence H2 is hereby accepted, in addition, based on the coefficient of determination (R^2) flood disaster characteristics only contribute a total of 13% of the variance in indirect effect on agriculture ($R^2 = 0.13$).

However, when the mediating variable (direct effect on agriculture DEA) was joined in the model the beta in the direct model reduced to 0.10 as shown in the Figure 8 below.

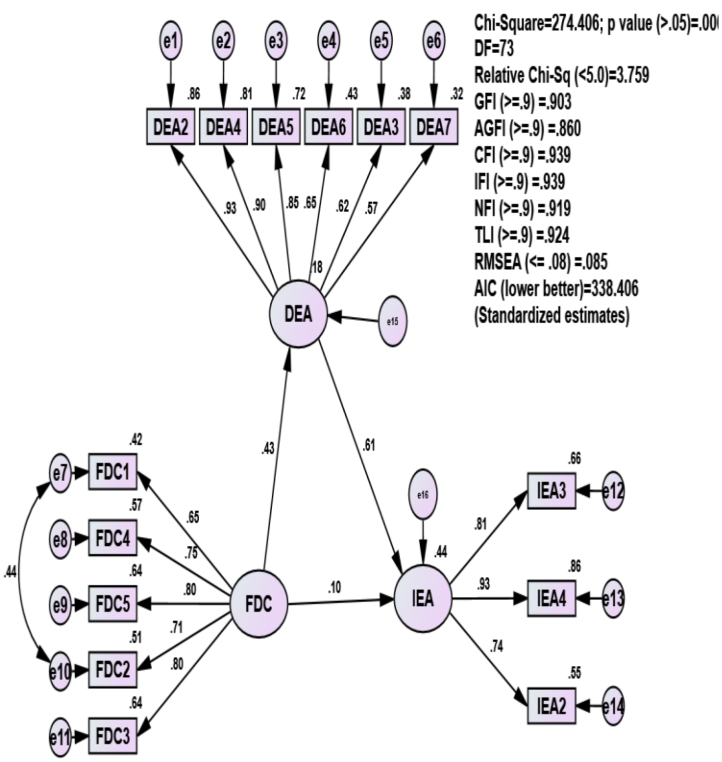

Figure 8: Path Diagram Showing Mediation Model

Table 6: Regression Weights for Mediation Model

Hypothesized Relationship	Unstandardized β	S.E.	Standardized β	C.R.	P
DEA<-FDC	**0.695**	**0.097**	**0.425**	**5.826**	*******
IEA<--FDC	**0.145**	**0.078**	**0.097**	**1.847**	**0.065**
IEA<-DEA	**0.563**	**0.052**	**0.615**	**10.918**	*******

The results for the mediation test presented in Table 4.22 and revealed that flood disaster direct effect on agriculture (DEA) mediates the relationship between flood disaster characteristics (FDC) and indirect effect on agriculture (IEA), This also indicates that negative effect on smallholder farmers' production activities, contribute highly to the indirect effect ($\beta = 0.615$, CR = 10.918 and $P < 0.000$), and H3 was also supported, similarly factors in the mediation model contribute a total of 44% of the variance in the indirect effect ($R^2 = 0.44$), which indicates that the mediation model is better and more robust than the direct model. These results has been corroborated with the previous studies which asserted that direct effect of flood lead to greater indirect ones (Carrera et al., 2013; Hasegawa et al., 2009; Israel & Briones, 2013).

12. Contribution of the Study

Most economic analysis of flood disaster impacts focuses too often on the direct physical effect only, neglecting the wider indirect ones resulting from the former one. This study therefore contributes to the literature by coming up with an integrated framework on flood disaster economic effect on smallholder agriculture depicting simultaneous relationship between flood disaster characteristics, direct and indirect effects of flood disaster concurrently. Although, the findings of this study are limited to the study area and their generalizability to other states, countries and/or regions is limited, however, the framework of this study could be used while assessing the effect of flood and other natural disasters in future researches.

12. Conclusion and Policy Implication

Based on the study findings, the results showed that, flood has a significant direct effect on agriculture in terms of damage to crops, farm inputs and infrastructures which in turn results to wider indirect effects consisting of decrease in food supply and high prices of goods, unemployment and low income among farmers. However, the findings of this study has several implications, first it could help policy makers to facilitate and improve on the flood disaster management practices involving both preparedness, mitigation, response and recovery activities in order to avoid future effects in the study area; second, it can give further insight to the academicians in which the methodology of this study could be applicable to other natural disaster (e.g. storm, drought, landslides, earthquakes, etc.). In addition as a follow-up to this study, future research should incorporate mitigation strategies and recovery need resources into the framework to determine their role as intervening variables (moderators) in lessening/reducing the direct and indirect flood disaster effect on agriculture respectively, as suggested by Lindell & Prater (2003).

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