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CONTENTS

ISSN: 0866-7756 **Số 8** - Tháng 7/2017

LUẬT

TRẦN THỊ TRÚC MINH

Một số bất cập và kiến nghị hoàn thiện pháp luật về quảng cáo thực phẩm chức năng
Shortcomings and recommendations to improve the law on advertising of functional foods9

DOÃN HỒNG NHUNG - LƯƠNG THANH BÌNH

Một số trao đổi về phương pháp giảng dạy và nghiên cứu khoa học về Luật Doanh nghiệp tại Việt Nam
Exchanges on methodology and scientific research on Law on Enterprise Law in Vietnam15

TRẦN LƯƠNG ĐỨC

Một số vấn đề pháp lý về công bố thông tin trên thị trường chứng khoán
Legal issues on information disclosure on the stock market23

TÀO THỊ HUỆ

Hoàn thiện phương pháp giảng dạy hợp đồng thương mại quốc tế và các giao dịch kinh doanh quốc tế
tại Trường Đại học Luật Hà Nội
Perfecting the teaching methods of international trade contracts and international business transactions
at Hanoi Law University29

LÊ THỊ THẢO

Những bất cập của pháp luật về tự chủ đại học và yêu cầu hoàn thiện
The inadequacies of the law of university autonomy and the requirement for better reform35

NGUYỄN VĂN VIỆT

Bàn về giải quyết tranh chấp hợp đồng mua bán hàng hóa
Discussing the settlement of disputes related to contracts for the sale of goods40

NGUYỄN VĂN VI

Giáo dục pháp luật trong Quân đội nhân dân Việt Nam: Thực trạng và giải pháp thúc đẩy
Legal education in the Vietnam People's Army: Situation and solutions45

VŨ CÔNG GIAO

Những thuận lợi và thách thức với việc xây dựng nhà nước kiến tạo phát triển ở Việt Nam
Building a constructive developmental state in Vietnam: Advantages and challenges54

VÕ THỊ KIM TUYẾN

Thực trạng các chính sách, pháp luật liên quan đến phát triển dịch vụ môi trường của Việt Nam hiện nay
và một số kiến nghị
Current situation of policies and laws related to development of Vietnamese environment services
and a number of recommendations62

HUỖNH TẤN ĐẠT

Giải pháp phòng ngừa người chưa thành niên phạm tội xâm phạm sở hữu ở Thành phố Hồ Chí Minh
Solutions to prevent teenagers committing property infringements in Ho Chi Minh City68

NGUYỄN VĂN NGHIỆP

Tội phạm có tổ chức và phòng ngừa tội phạm có tổ chức
Organized crime and measures to prevent organized crime.....75

KINH TẾ

HÀ QUANG THANH

Phân cấp và mối quan hệ giữa Trung ương với chính quyền địa phương trong phát triển bền vững
Decentralization and the relationship between central and local authorities in sustainable development.....82

ĐÀO HỒNG VÂN

Phân tích kết quả chi trả dịch vụ môi trường (PES) tại Việt Nam sau 10 năm thực hiện
Analysis of PES results in Vietnam after 10 years of implementation88

NGUYỄN QUYẾT THẮNG - LƯU HIẾU TRUNG

Nâng cao chỉ số năng lực cạnh tranh cấp tỉnh (PCI) của tỉnh Long An
Improving provincial competitiveness index (PCI) of Long An Province.....93

NGUYEN TIEN HOANG

International market entrance through franchising: Experience of multinational corporations and lessons for Vietnamese enterprises
Thâm nhập thị trường quốc tế bằng hình thức nhượng quyền thương mại:
Kinh nghiệm của các công ty đa quốc gia và bài học cho doanh nghiệp Việt Nam101

NGUYỄN HUY HOÀNG

Chiến lược marketing nhằm thu hút đầu tư FDI của một số quốc gia, địa phương điển hình và bài học tham khảo cho tỉnh Hà Tĩnh
Marketing strategy to attract FDI: Models and lessons for Ha Tinh province.....108

NGUYỄN VĂN CƯỜNG - PHAN THỊ THU HƯỜNG - NGUYỄN THỊ THÙY LIÊN - LÊ KIM LIÊN - TÔN ANH HẢI

Phân tích lợi ích thiệt hại và các yếu tố ảnh hưởng đến quyết định chuyển đổi cây trồng từ cà phê sang hồ tiêu của nông hộ tại huyện Krông Búk, tỉnh Đắk Lắk
Analyzing the cost-benefit and factors influencing the farmers' decision to convert coffee to pepper crops in KrongBuk district, Dak Lak Province114

VÕ VĂN BÌNH

Thực trạng và giải pháp tăng cường nguồn vốn đầu tư phát triển kinh tế biển, đảo Việt Nam
The current situation and solutions to increase investment for the economic development of sea and islands in Vietnam...123

LÊ KIM LONG

Phân tích hiệu quả kinh tế - môi trường trong nuôi trồng thủy sản:
Trường hợp nghề nuôi tôm thẻ chân trắng thâm canh tại tỉnh Ninh Thuận
Analyzing the environmental and economic efficiency in the aquaculture industry:
The case of the intensive white-leg shrimp farming in Ninh Thuan Province.....129

NGUYỄN PHÙNG QUÂN

Nghiên cứu đánh giá thực trạng lao động việc làm của người dân tộc thiểu số
Studying the current employment situation of ethnic minority workers136

ĐẶNG THANH LIÊM

Nghiên cứu xây dựng marketing địa phương nhằm phát triển du lịch tỉnh Bến Tre
Doing local marketing to develop the tourism sector of Ben Tre Province.....142

TRAN HOAI NAM - NGUYEN VAN CUONG - DO MINH HOANG

The effects of drought in adaptability of farmers' agricultural production:

A case study of Ninh Thuan Province

Ảnh hưởng của hạn hán đến khả năng thích ứng của nông hộ trong sản xuất nông nghiệp:

Trường hợp nghiên cứu tại tỉnh Ninh Thuận149

LÊ THỊ THU HƯƠNG

Phát triển Sở giao dịch hàng hóa nông sản ở Việt Nam: Thực trạng và giải pháp

Developing the Commodity Exchange of Agricultural Products in Vietnam: Situation and solutions158

ĐỖ THỊ HÒA NHÃ

Các yếu tố tác động đến xuất khẩu nông sản của Việt Nam vào thị trường EU: Cách tiếp cận từ mô hình trọng lực

The factors affecting Vietnam's agricultural exports to the European Union: A gravity model approach163

LÊ NGỌC THƠM

Cơ hội và thách thức trong thu hút vốn đầu tư trực tiếp nước ngoài (FDI) tại Việt Nam.....168

Opportunities and challenges for vietnam in attracting foreign direct investment

NGUYỄN ĐỨC NHUẬN

Các yếu tố tác động đến thu hút đầu tư trực tiếp nước ngoài ở vùng kinh tế đồng bằng sông Hồng

Factors influencing the attraction of foreign direct investment in the Red River Delta economic zone173

NGUYỄN THỊ DƯƠNG NGA

Giải pháp tăng cường liên kết trong tiêu thụ một số sản phẩm nông nghiệp, thủy sản chủ yếu tại tỉnh Ninh Bình

Solutions to enhance linkages in marketing of key agricultural and fishery products in Ninh Binh province184

TRẦN HOÀI NAM - NGUYỄN THỊ THU HÀ

Đánh giá khả năng thích ứng của nông hộ đối với xâm nhập mặn tại Cù Lao Dài, huyện Vũng Liêm, tỉnh Vĩnh Long

Evaluating the farmer's adaptability to saltwater intrusion in the Cu Lao Dai, Vung Liem district, Vinh Long province190

NGUYỄN THỊ PHƯƠNG HOA

Chính sách của Liên bang Nga đối với ASEAN giai đoạn 2000 – 2014

Russian policy towards ASEAN in the period of 2000 – 2014.....196

QUẢN TRỊ - QUẢN LÝ**VÕ VĂN DỨT**

Các yếu tố ảnh hưởng đến nhu cầu đào tạo của viên chức tại huyện Cao Lãnh, tỉnh Đồng Tháp

Factors that affect the training needs of officials in Cao Lanh District, Dong Thap Province202

NGUYỄN THỊ THU TRANG

Sinh viên thất nghiệp sau khi ra trường - Nguyên nhân và cách khắc phục

Unemployed students after graduation - Causes and Solutions208

LÊ HIẾU HỌC

Áp dụng TQM trong trường đại học: Vai trò của giảng viên và quan điểm chú trọng sinh viên

Applying TQM in the University: The Role of Lecturers and Student's Focuses.....214

NGÔ SỸ TRUNG

Phân tích một số ưu điểm và hạn chế trong thực hiện trách nhiệm xã hội của doanh nghiệp tư nhân

Analyzing the advantages and disadvantages of private enterprises' implementation of corporate social responsibility ...220

HÀ NAM KHÁNH GIAO - TRƯƠNG NGỌC HƯƠNG

Sự hài lòng về chất lượng dịch vụ Khoa Nội tổng quát - Bệnh viện Chợ Rẫy

Satisfaction on service's quality of Department of General Internal - Chợ Rẫy Hospital225

THE EFFECTS OF DROUGHT IN ADAPTABILITY OF FARMERS AGRICULTURAL PRODUCTION: A CASE STUDY OF NINH THUAN PROVINCE

● TRAN HOAI NAM, NGUYEN VAN CUONG, DO MINH HOANG

ABSTRACT:

In this study, the multinomial logit model was applied to measure adaptability of farmers agricultural production with drought. The data was collected by interviewing 246 farmers (5/2016). Key results showed that adaptability of farmers agricultural production is low, as well as a level impact of drought increased the probability of stop production in Bac Ai district or change production in Ninh Hai and Ninh Phuoc district. The adaptability of farmer with drought affected by level impact of drought, area cultivated, drought tolerant plant or not.

Keywords: Drought, adaptation, multinomial logit model.

1. Introduction

Climate-related natural disasters (drought, flood, and typhoon) are principal sources of risk and uncertainties in agriculture. Drought has emerged as a major worldwide threat to crop production, especially in areas where irrigation is an inevitable aid to agriculture. The Crop face drought either due to impaired water supply to roots or higher transpiration rate (Manivannan et al. 2007). Drought influences the growth events, nutrient uptake and metabolism, and the crop productivity (Engelbrecht et al. 2007, Farooq et al. 2009).

In the last 50 years, Viet Nam suffered around 36 drought events. In the context of climate change, the temperature rises, evaporation greater, more extreme rainfall distribution and drought risk of

more intense, major impact on agricultural production (Truong, 2015).

Ninh Thuan is known as severe climate areas. In dry season, prolonged drought, water shortage are frequent. Almost people are farmer about agriculture, forestry and aquiculture. So, drought have impacted to social economic in area. In Viet Nam, drought is third calamity of three calamity (drought, flood and storm). However, drought is the most calamity in Ninh Thuan province. At the present time, the provinces crop area directly and indirectly affected to over 700 billion dong, the total area cant be production 5,775 ha and 2,515 cattle were died, the situation of drought is growing sandy desert and difficult cultivation (Department of agriculture and rural development, 2015). The

purpose of this research assess the effects of drought in adaptability of farmers' agricultural production. A farmer may have the choice to adopt a water-saving technology that reduces his water application rates. More efficient technologies may allow the farmer to survive through drought periods by reducing water applications to minimum possible levels (Schuck et al, 2005).

2. Literature review

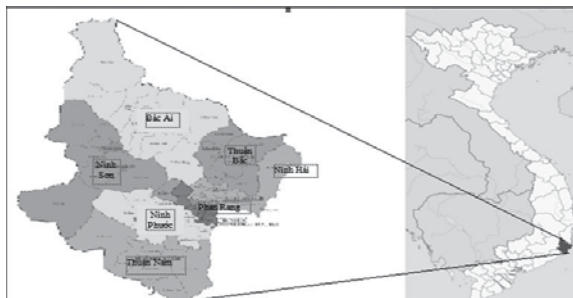
Conceptually, drought is considered to describe a situation of limited rainfall that is substantially below what has been established to be a normal value for the area concerned, leading to adverse consequences on human welfare. Although drought is a climatically induced phenomenon, its impact depend on social and economic context. Three generally used definition of drought are based on meteorological, hydrological, and agricultural perspectives (Wilhite and Glantz, 1985).

Agricultural drought is said to occur when the soil moisture is insufficient to meet crop water requirements resulting in yield losses. As the effect of rainfall deficiency on crops also depends on soil and crop characteristics, the definition of agricultural drought requires consideration of actual and potential evapotranspiration, soil water deficit, and production losses simultaneously.

Schuck, 2005, using survey data for adoption of efficient irrigation technology in drought-affected regions of Colorado, find that drought indeed significantly increases the percentage of farms adopting modern irrigation technologies, with the farmers having the most reliable sources of water being the major adopters.

3. Study area

Figure 1: Study area



Ninh Thuan Province is located in central Viet Nam, bordered on the east by the South China Sea, on the west by Lam Dong Province, on the north by Khanh Hoa Province and on the south by Binh Thuan Province. The province has an area of 3,358 km² and is divided into seven administrative districts. The estimated population is 590,377 in 2014 with about 213,716 (36.20%) urban residents and 376,660 (63.80%) rural residents.

Ninh Thuan Province has scarest quantity of overground water in the country, with the annual rainfall of about 1.100 mm. In fact, the rainfall is distributed irregularly spatially and timely. Precipitation decreases from plain to mountainous place. The upstream areas of Cai river have rainfall of over 2.000 mm while the coastal plain have only rainfall of 700 mm. The Cai river is crucial with total area of 3.043 km², 105 km length, supply mainly water during drought season. The flow of Cai river distributes during two different seasons. The flow of river is dense but focus on short time with the flood peak of 5.000 m³/s. The flow of river in dry season is only 3,35m³/s. Ninh Thuan Province annual suffered the impact of natural disasters due to drought, water shortage (Dang, 2015).

4. The method and data source

4.1. Data source

This research is based on information collected from household survey of 246 farmers, collected randomly from Bac Ai District (high drought), Ninh Hai District (medium drought) and Ninh Phuoc district(non drought). Data were collected in through household survey with a questionnaire, which contained questions to provide answers. In this study, Limdep 9.0 was used to estimate the multinomial logit model.

4.2. The method

The Multinomial Logit (MNL) model is one of the most important models for multicategorical responses. This model is used to make predictions about and explain relationships among variables in awide variety of areas, including business, economics, education, health care, and geography. As it is an enhanced version of logistic regression,

multinomial logistic regression shares the problem associated with logistic regression but with more complications involved (Pannapa, 2013).

The MNL model is expressed as follows:

$$\text{Log} \left(\frac{P_{ij}}{P_{i1}} \right) = x_i \beta_j \text{ for } j = 1, \dots, j, i = 1, \dots, N$$

Where, P_{ij} is $\text{Prob}(Y=j/x)$, which is obtained as follows:

$$p(y = j / x_i) = \frac{\exp(x_i \beta_j)}{1 + \sum_{j=1}^j \exp(x_i \beta_j)}$$

We can begressio by the method of maximum likelihood. In this model, the probability is obtained as follows:

$$p(Y = 1) = \frac{1}{1 + \sum_{j=1}^j \exp(x_i \beta_j)}$$

$$p(Y = j) = \frac{\exp(x_i \beta_j)}{1 + \sum_{j=1}^j \exp(x_i \beta_j)}$$

The benefit of using multinomial logit model is that it models the odds of each category relative to a baseline category as a function of covariates, and it can test the equality of coefficients even if confounders are different (M. R. Kohansal, 2013).

In this study, the Multinomial Logit (MNL)

model is used to analyse the factors influencing drought in adaptability of Farmers agricultural production in Ninh Thuan Province. Variables was defined in the table 1.

Marginal probabilities of choice (marginal effects) can be calculated from equation below:

$$\frac{\partial P_j}{\partial X_k} = P_j (\beta_{jk} - \sum_{j=1}^j P_j \beta_{jk})$$

We can find changes in probabilities for primary choice in adaptability farmers, while holding all other explanatory variables fixed. The empirical specification for examining the influence of explanatory variable which are described in table 1 on the choice of Y is gives as follows:

5. Result and discussion

$$Y_{i=1,2..j} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 D_1 + \beta_7 D_2 + \beta_8 D_3 + \varepsilon$$

5.1. Farmers socioeconomic characteristics

The summary of the socioeconomic characteristics is presented in Table 2. A comparative analysis of the socioeconomic variables between groups showed that majority of the all farmer are male, where 80,49% and 85,37% of Ninh Phuoc Distric, Ninh Hai Distric. These male farmers are engaged in agricultural farming rather female headed farmers and they are more active in taking adaptation actions to cope with

Table 1. Variables used in the multinomial logit model and their expected signs

Variables	Definition and measurement	Expected sign
Y	1: Stop production	
	2: Change production	
	3: Continue production (base outcome)	
X1	Farm scale (1000m2)	+
X2	Agricultural income (million vnd)	+
X3	Land quality (1 low; 2 medium; 3 high)	+
X4	Level impact of drought (1 low impact; 2 medium impact; 3 high impact)	-
X5	Education of the household head (years)	+
D1	Area cultivated (1: Bac Ai - strongly drought; 0: others (Ninh Hai- medium drought; Ninh Phuoc - low drought))	-
D2	Dummy for plant (1: drought tolerance plant; 0: others)	+
D3	Ethnic (1: Kinh people; 0: others)	+

Table 2. Socioeconomic characteristics of the farmer

Category	Bac Ai		Ninh Hai		Ninh Phước	
	N	ratio(%)	N	ratio(%)	N	ratio(%)
1. Gender						
Male	37	45,12	70	85,37	66	80,49
Female	45	54,88	12	14,63	16	19,51
2. Age						
<26 years	14	17,07	1	1,22	2	2,44
26 – 50 years	54	65,85	43	52,44	60	73,17
≥ 50 years	14	17,07	38	46,34	20	24,39
3. Experience						
<5 years	11	13,41	4	4,88	14	17,07
5-10 years	22	26,83	9	10,98	23	28,05
10- 15 years	20	24,39	11	13,41	16	19,51
15-20 years	5	6,10	10	12,20	6	7,32
≥ 20 years	24	29,27	48	58,54	23	28,05
4. Education						
Illiterate	32	39,02	16	19,51	1	1,22
Primary school	14	17,07	21	25,61	21	25,61
Secondary school	14	17,07	33	40,24	26	31,71
Hight school & Graduate	22	26,83	12	14,63	34	41,46
5. Annual income (agricultural sources)						
<20 million vnd	60	73,17	32	39,02	6	7,32
20 – 40 million vnd	14	17,07	33	40,24	18	21,95
40- 60 million vnd	5	6,10	9	10,98	11	13,41
60- 80 million vnd	0	0,00	4	4,88	11	13,41
≥ 80 million vnd	3	3,66	4	4,88	36	43,90
Total	82	100	82	100	82	100

Source: Research findings

drought instead of female farmers in these areas.

Age is an important factor which helps to understand the real scenarios happening in drought issues. Table 2 shows that three groups farmers age lies between 26 and 50 years. This indicates that the middle aged farmers are likely to be more active in applying farming experiences better, so older farmers are able to assess the characteristics of modern technology than younger farmers. Moreover, education not only increases the level awareness, but also higher income positively affects public perception of drought. It can be seen that education level of the household head has

completed secondary school, but 39,02% of Bac Ai Distric farmers are illiterate. Finally, income is the most imperative issue that protects and ensures farmers livelihoods from any consequence that arises from drought. Data shows the annual income of different farmer groups. It is evident that 90,24% and 79,26% of farmers annual income is less than 40 million vnd in Bac Ai distric and Ninh Hai Distric, while 43,9% of farmers annual income is more than 80 million vnd in Ninh Phuoc distric. In rural areas where agricultural production is a major source of income. A decrease in agricultural income will reduce adaptable to drought.

Table 3. Cultivated area

Category	Bac Ai		Ninh Hai		Ninh Phước	
	N	ratio(%)	N	ratio(%)	N	ratio(%)
<=1ha	10	12,20	18	21,95	11	13,41
1ha-3ha	24	29,27	58	70,73	44	53,66
>=3ha	48	58,54	6	7,32	27	32,93
Total	82	100	82	100	82	100

Source: Research findings

Regarding land holding size could be either risk-increasing or risk-reducing. Because their small pieces of land did not allow them to invest in these activities. Therefore, it is evident that represents different farmers group, 70,07% and 53,66% of farmers land is between 1 ha and 3 ha in Ninh Hai District and Ninh Phuoc District, but in Bac Ai District 58,54% of farmer's land more than 3 ha.

Table 4. Farmers perception on drought issues

Category	Bac Ai		Ninh Hai		Ninh Phước	
	N	ratio(%)	N	ratio(%)	N	ratio(%)
Temperature is changing						
Yes	79	96,34	80	97,56	80	97,56
No	3	3,66	1	1,22	2	2,44
No idea	0	0	1	1,22	0	0
Number of sunny days						
Increasing	81	98,78	81	98,78	78	95,12
Decreasing	0	0	0	0	1	1,22
No change	1	1,22	1	1,22	3	3,66
No idea	0	0	0	0	0	0
Munber of rainfall days						
Increasing	0	0	1	1,22	1	1,22
Decreasing	81	98,78	80	97,56	79	96,34
No idea	1	1,22	1	1,22	2	2,44
Rainfall intensity						
Increasing	0	0	0	0	1	1,22
Decreasing	77	93,90	78	95,12	75	91,46
No change	1	1,22	2	2,44	3	3,66
No idea	4	4,88	2	2,44	3	3,66
Water is used						
Enough	2	2,44	7	8,54	20	24,39
No change	10	12,20	30	36,59	42	51,22
Not enough	70	85,37	45	54,88	20	24,39
Groundwater						
No change	8	9,76	4	4,88	22	26,83
Low decreasing	28	34,15	49	59,76	45	54,88
High decreasing	46	56,10	29	35,37	15	18,29
Total	82	100	82	100	82	100

Source: Research findings

5.2. Farmers perception on drought

An effective drought risk reduction approach is essential not only in order to reduce drought impact but also to put communities back on the track of development. In this study, the farmers are asked about their perception on drought. Table 4 shows that drought is well perceived by farmers in Bac Ai, District Ninh Hai and Ninh Phuoc. Farmers interviewed in this research gave feedback on temperature, number of rainfall days, rainfall intensity, water used and specially groundwater. Groundwater is extensively use for agricultural purposes. This groundwater is mainly recharged through rainfall during the monsoon season. However, lack of rainfall during the monsoon season cannot revitalize the groundwater for irrigation purposes, is not completely replenished during the drought year causing groundwater depletion of this region.

5.3. Explaining farmers adoption decisions of drought

The estimated results from the multinomial logit model are represented in table 5. Base on R2 pseudo statistics, it can be clearly seen that estimated multinomial logit model is a suitable regression and independent variables of the model explain variation of dependent variable in three groups. Moreover, the chi-square value of 131,10 showed that likelihood ratio statistics are highly significant (0,00001) suggesting the model has a strong explanatory power.

It is clear from Table 5 that X₃ (land quality), X₄ (level impact of drought), X₅ (education of the household head), X₆ (area cultivated), D1 (dummy for plant) variables affected farmers primary choice of stopping production over the farm to continue in the first equation. In other words, X₂ (agricultural income), X₄ (level impact of drought), X₆ (area

Table 5. Multi logistic model regression results

Variable	Y=1		Y=2	
	Coefficient	p-level	Coefficient	p-level
C	-1,698	0,409	-2,732	0,017
X1	-0,022	0,680	-0,092	0,101
X2	-0,020	0,268	-0,008*	0,064
X3	-0,875**	0,036	0,06	0,806
X4	1,704***	0,003	1,355***	0,000
X5	0,098*	0,081	-0,012	0,783
D1	-1,561*	0,083	-0,703*	0,100
D2	-2,022***	0,002	-2,054***	0,000
D3	0,914	0,272	2,115***	0,001
Number of observations		246		
Pseudo R-Square				
Cox and Snell		0,413		
Nagelkerke		0,489		
McFadden		0,286		
Model fitting information				
Likelihood ratio test	Chi-square=131,10	DF= 16	sig< 0,00001	

Source: Multinomial logit model output

(Notes: *, **, *** indicate the significance level of 10%, 5%, 1%; Y= 3 (farm to continue) base outcome)

cultivated), D_1 (dummy for plant), D_2 (ethnic) variables affected farmers second choice of change production over the farm to continue. Income variable significantly influenced the change production at 10% level but not significant in stop production, farmers who have high agricultural income is conscious about change production than farmers with low agricultural income.

From Table 5, it is obvious that the sign of level impact of drought variable is positive and statistically significant in both equations. These show that an increase in level impact of drought increased the probability of stop production in Bac Ai distric or change production in Ninh Hai and Ninh Phuoc Distric.

In this model, marginal effect measure the change in the probability of the farmers primary preference outcome with respect to a change in each explanatory variable. Results of calculating variables marginal effects are presented in table 6. Marginal effect of farm scale variable indicates that an increase in farm scale by 1000 m² decreased the probability of choosing stop production and change production by 0,05 and 1,76%, respectively.

Also, marginal effect of education of the household head variable indicated that higher education gives farmers the ability to interpret and respond to new information much faster than their counterparts with lower education. An increase in education level by one year increased the probability of choosing non production by 0,25%,

Table 6. Marginal effects from the multinomial logit

	Marginal effects		
	Y=3	Y=1	Y=2
X1	0,0175	-0,0005	-0,0176
X2	0,0186	-0,0222	-0,0014
X3	0,0048	0,0334	0,0174
X4	-0,2839	0,0025	0,2505
X5	0,0004	0,0025	-0,0029
D1	0,1595	-0,0342	-0,1253
D2	0,4201	-0,0366	-0,3834
D3	-0,4112	0,0862	0,4025

Source: Multinomial logit model output

respectively. However, the probability of choosing farm to continue increases by 0,04%. At last, the variable of plant shows that the plant drought will decrease the probability of non and change production by 3,66 and 38,34%, respectively. On the other hand, the probability of choosing farm to continue increases by 42,01%. Also, instead of calculation of marginal effect for each variable, we can calculate and interpret odds ratios. The interpretation of the results of marginal effects and odds ratio leads the same direction.

According to Table 7, it is clear that the overall predictive power of the estimated multinomial logit model is 69,1%. It mean that this model and its coefficients could appropriately predict the farmers adaptive drought. Results of predictive power are represented in table 7 individually for each group. Base on this table, statistics of prediction power for farmer who chose farm to continue or change production was more than those who chose non production.

Table 7. Classification of farmers for testing data based on estimated MNL model

Criterion	Number of cases	Predictive power of MNL model		
		Y=1	Y=2	Y=3
Y=1	27	10 (37,03%)	11 (40,74%)	6 (22,23%)
Y=2	80	4 (5,00%)	53 (66,25%)	23 (28,75%)
Y=3	139	6 (4,32%)	26 (18,70%)	107 (76,98%)
Percentage of right prediction		69,10%		

Source: Multinomial logit model output

5. Conclusions

Research shows the impact of drought to each region of Ninh Thuan Province and the factors that affect the ability of farmers to respond to drought. In the survey region includes Bac Ai, Ninh Hai, and Ninh Phuoc District. Bac Ai is where most powerful impact-resistant by rought, and little influenced as Ninh Phuoc District. So, Ninh Phuoc has no farmers choose out of production and this area is also the chosen rate production continued to occupy the highest.

The research results showed that the production area shall not affect the option to continue or stop production or switch crops of farmers, which is important to the extent of the impact of the drought to individual farmers, what farmers are producing crops, plants that are drought resistant or non - drought. Possibilities for production of farmers were mainly concentrated in Bac Ai, where a severe drought, the majority of crop planting non-drought (rice), bad soil quality are difficult to convert to other crops. So that, to diminish of drought influence and raise to cope with drought better, local authorities must upgrade current irrigational work to help reserve water better, provide adequate water for all farmer and especial distant farmers

Strong impact factor to the conversion plant is the nation. If the minorities, the rate of conversion options is very low because of the ethnic minorities are usually less liable to change its manufacturing practices. Therefore, local authorities need to improve education and encourage the minority to change crops to suit the current drought situation.

All in all, adaptability of farmers agricultural production is low. They don't have much choice because the level education is low, soil quality is poor. Most of them accept continued to produce because agricultural production is the main source of income of the people of this place, if not produced, they are difficult to do other work to have more revenue ■

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Corresponding author:

1. MA. TRAN HOAI NAM

Department of Economics and Agriculture; Faculty of Economics, Nong Lam University

Email: hoainam@hcmuaf.edu.vn

2. MA. NGUYEN VAN CUONG

Department of Economics and Agriculture; Faculty of Economics, Nong Lam University

Email: nguyenvancuong@hcmuaf.edu.vn

3. MA. DO MINH HOANG

Department of Economics and Agriculture; Faculty of Economics, Nong Lam University

Email: dominhhoang@hcmuaf.edu.vn

ẢNH HƯỞNG CỦA HẠN HÁN ĐẾN KHẢ NĂNG THÍCH ỨNG CỦA NÔNG HỘ TRONG SẢN XUẤT NÔNG NGHIỆP: TRƯỜNG HỢP NGHIÊN CỨU TẠI TỈNH NINH THUẬN

- Ths. **TRẦN HOÀI NAM**
- Ths. **NGUYỄN VĂN CƯỜNG,**
- Ths. **ĐỖ MINH HOÀNG**

Bộ môn Kinh tế nông lâm, Khoa Kinh tế
Trường Đại học Nông lâm TP. Hồ Chí Minh

TÓM TẮT:

Nghiên cứu này đã sử dụng mô hình hồi quy đa thức nhằm đo lường khả năng thích ứng với hạn hán của nông hộ trong sản xuất nông nghiệp. Số liệu được thu thập bằng cách phỏng vấn trực tiếp 246 nông hộ (5/2016). Kết quả nghiên cứu cho thấy, khả năng thích ứng của nông hộ đối với hạn hán là thấp, cũng như khi có sự gia tăng tác động của hạn hán sẽ làm tăng xác suất ngưng sản xuất của các nông hộ tại huyện Bác Ái, hoặc làm tăng khả năng chuyển đổi cây trồng của các nông hộ tại huyện Ninh Hải và Ninh Phước. Các nhân tố ảnh hưởng đến khả năng thích ứng của nông hộ đối với hạn hán là biến mức độ hạn hán, khu vực sản xuất, đặc tính của cây trồng chịu hạn hay không chịu hạn.

Từ khóa: Hạn hán, khả năng thích ứng, mô hình logit đa thức.