

RESEARCH PAPER

Enhancing Resilience in Coromandel's Coastal Agricultural Belt: A Study on Crop Diversification for Cyclone Risk Mitigation

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ABSTRACT

The coastal agricultural belt of the Coromandel region is very vulnerable to cyclonic damage. The ill effects of cyclonic damage could be lessened effectively if crop diversification is adopted. But, in the region, most of the farmers either cultivate annuals or perennials as Monocrop. Monocropping would largely reduce the farmers' resilience. In light of this, this study was conceived with the objectives to assess the various factors influencing the farmers' awareness of crop diversification as a method to mitigate risk and to prioritize the primary factors contributing to the non-adoption of crop diversification on a cluster-specific basis in the cyclone prone Coromandel coast of Tamil Nadu. The Coromandel coast formed the universe of the study. The multistage stratified random sampling approach was employed to select sample respondents. The ultimate sample size was 400. The required primary data were collected for the study through a pre-tested, structured interview schedule administered to sample respondents. The logit analyses indicated that the awareness of farmers on such crop diversifications was majorly and positively influenced by agri-extension activities. Further, Garrett analyses revealed that, by and large, the reason 'Fear of production failure' was the principal cause for the non-adoption of crop diversification. Hence, the study concluded that the farmers need to be imparted with the production techniques of the alternative crops that could be taken up in the Coromandel agricultural belt and encouraged to cultivate the crops through an enhanced extension approach specially intended for this purpose.

HIGHLIGHTS

- ① Crop diversification is essential for reducing cyclonic damage in the Coromandel region's coastal agricultural belt.
- ② Awareness of crop diversification among farmers is primarily influenced by agricultural extension activities.
- ③ Fear of production failure is the principal reason for the non-adoption of crop diversification.

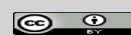
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India's susceptibility to cyclones and floods is significantly influenced by its geographical location, being bordered by water on three sides. Among the states most severely impacted by cyclones and floods are Tamil Nadu, Andhra Pradesh, West Bengal, Kerala, Odisha and Gujarat (Ashwani Kumar, 2014). Tamil Nadu has a long history of susceptibility to tropical cyclones. The

Coromandel coast, in particular, has experienced frequent cyclonic storms, resulting in devastating impacts occurring approximately every two years.

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There have been instances where the coast has suffered multiple hits within a single year. Tamil Nadu encompasses a total geographical area of 13 million hectares and boasts a coastline spanning 1076 kilometres, constituting approximately 15 per cent of India's total coastline. Over recent years, Tamil Nadu has faced the impact of several tropical cyclones including Gaja in 2018, Ockhi in 2017, Vardha in 2016, Nilam in 2012, Thane in 2011, Jas in 2010 and Nisha in 2008 (NDMA, 2019). Among these, Thane, Nilam and Gaja cyclones caused severe damage to the coastal agriculture of Tamil Nadu.

On one side, at a macro view, such cyclones seem to impact so negatively on coastal agriculture, which needs to be restored, and on the other side, at a micro level, the livelihood security of each farmer in the region experiences a significant and severe blow, which also requires definite attention. Moreover, the damage has escalated to an intolerable level, primarily because a majority of the farmers were practicing a monocropping system. Crop diversification is largely overlooked in this region, with farmers lacking awareness of potential alternative crops suitable for cultivation on their land, as they have adhered to the same conventional system for many decades.

In general, existing statistics unveil that, coastal districts in Tamil Nadu engage in agricultural activities encompassing a diverse range of crops, viz., cereals (9 Nos.), pulses (8 Nos.), vegetables (16 Nos.), fruits (17 Nos.) and many number of oilseed and tree crops, notably cashew and Jackfruit, across extensive areas. However, detailed information pertaining to specific villages and individual farms highlights an extremely minimal degree of crop diversification. It is imperative to investigate and address this issue, especially in regions susceptible to cyclones, where crop diversification could prove to be a highly beneficial solution.

OBJECTIVES

The study has been formulated with the following objectives in consideration of this background:

- ♦ To assess the various factors influencing the farmers' awareness of crop diversification as a method to mitigate risks.

- ♦ To prioritize the primary factors contributing to the non-adoption of crop diversification on a cluster-specific basis.

MATERIALS AND METHODS

Study Area and Sampling Design

Cyclone-prone Coromandel Coast formed the universe of the study. In accordance with the multistage stratified random sampling technique, as the first stage of sampling, three coastal districts of Tamil Nadu, namely, Cuddalore, Villupuram and Nagapattinam were purposively selected for two reasons, viz., firstly, the study intended to focus exclusively on the coastal agro-climatic issues of Tamil Nadu state alone and secondly, out of the thirteen Coromandel coastal districts of Tamil Nadu, the districts which encountered with higher number of cyclonic land falls in the recent decades are these three referred districts.

As the second stage of sampling, all thirteen coastal blocks of the selected districts, reclassified into five major agronomically homogenous village clusters, were considered for the study. The considered 13 blocks were Cuddalore, Kurinjipadi, Parangipettai, and Panruti of Cuddalore district, Marakkanam of Villupuram district and Kollidam, Sirkazhi, Sembanarkoil, Nagapattinam, Keelaiyur, Thalainayar, Thirumarugal and Vedaranyam of Nagapattinam district. In the third stage of sampling, from each cluster, 80 farmer respondents were selected at random. The ultimate sample size in total was 400.

The data set was subjected to a 'Z' test analysis to examine the homogeneity with respect to the mean values of different variables considered for the study.

Identification of Homogenous Village Clusters

Out of 730 villages, 647 agriculturally active villages were only considered for regrouping. The grouping was done considering the cropping pattern, source of irrigation and other important agronomical features. The village list was prepared, and the micro-level details (Cropping pattern, Source of irrigation, Soil type and other agronomic features) on each village were collected from the offices of the State Agricultural Department and Office of State Horticultural Department in the concerned

district and villages with the support of Assistant Agricultural Officers in the respective villages. The secondary data collected were tabulated, and using the master table prepared, the villages were classified into five different clusters in consultation with the agronomists. The clusters were designated as Cluster I, Cluster II, Cluster III, Cluster IV and Cluster V and their important features are described in Table 1.

Data

In accordance with the adopted stratified random sample technique, eighty respondents from each of the five clusters were selected, and data were obtained by the personal enumeration method. The reference year for the study is the agricultural year 2020-21.

Assessment of Awareness on Crop Diversification with Logit Model

The study used a logistic regression model to measure the relative influence of different factors contributing to farmers' awareness of the importance of crop diversification in mitigating risks.

$$L_i = \ln \left[\frac{P_i}{1 - P_i} \right] = \beta_1 + \beta_2 X_i + u_i \quad \dots (1)$$

In order to calculate the model, we require not only the X_i variables but also the corresponding *logit* values (L_i). However, we're encountering challenges at this stage. When we possess information about individual respondents, P_i equals 1 if the respondent is aware and 0 otherwise. Yet, directly inputting these values into the logit L_i results in the following:

$$L_i = \ln \left(\frac{1}{0} \right) \text{ for the respondent being aware}$$

$$L_i = \ln \left(\frac{0}{1} \right) \text{ if otherwise}$$

Clearly, these statements hold no significance. Consequently, when dealing with data at the micro or individual level, the standard OLS routine fails to estimate (1). In such cases, turning to the maximum likelihood approach might be necessary to determine the parameters.

In the previously discussed *Logit* framework, the study has proposed that the probability of being aware of the crop diversification concept (L_i) depends upon attributes like Age, Education, Size of the Farm, Earners in the family, Agri extension meetings attended, Labour scarcity, Water Scarcity and Ratio of non-farm income to farm income. The dependent variable is a binary qualitative variable indicating whether the respondent is aware or unaware of the concept of crop diversification. The respondents who know about the merits of crop diversification in risk mitigation are considered as "farmers who are aware" or otherwise. With regard to the selection of explanatory variables, those were decided based on the information obtained during the pilot survey. Also, the variables were decided and accommodated finally in the model by considering the degree of multicollinearity between them by examining the correlation co-efficients.

The index variable P_i , which determines the respondent's awareness, has been structured as a linear function involving independent variables. Consequently, the logistic regression model is

Table 1: Characteristic Features of Different Clusters

Particulars	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
No. of Villages	275	192	82	53	45
Existing Cropping Pattern	Paddy-Paddy-Pulse	Paddy (Samba) followed by Pulse	Paddy-Paddy-Paddy	Perennials	Single Paddy (Samba)
Dominant Crop	Paddy	Paddy	Paddy	Cashew and Coconut	Paddy
Source of Irrigation	Borewell and Canal; Dug open well in a limited area	Borewell and Canal; Dug open well in a limited area	Borewell; Canal in a limited area	Borewell	Canal
Soil Type	Clay loam	Clay loam and Sandy loam	Clay loam; Black soil and Sandy loam in certain pockets	Red loam	Sandy loam

defined accordingly.

$$L_i = a_i + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \mu_i \quad \dots (2)$$

where,

a_i = Constant

Z_1 = Age of the respondents, in years

Z_2 = Education, in years of schooling

Z_3 = Size of the farm, in acres

Z_4 = Earners in the family, in numbers

Z_5 = Agri extension meetings attended, in numbers

Z_6 = Labour scarcity (1 for yes, otherwise takes 0)

Z_7 = Water scarcity (1 for yes, otherwise takes 0)

Z_8 = Ratio of non-farm income to farm income

b_i 's = Parameters to be estimated

μ_i = Error term.

Ranking of Reasons for Non-adoption of Crop Diversification Using Garrett Ranking Technique

The major reasons for the non-adoption of crop diversification, as perceived by the farmers, have been ranked and analysed using this technique. The responses were obtained from all respondent farmers irrespective of their level of diversification.

The ranking represents how respondents prioritize their thoughts and emotions. Garrett and Woodworth (1971) outlined a method to score rankings when the number of ranked items varies among respondents. The procedure used for conversion was as follows.

As a first step, the percentage position of each rank was determined using the following formula:

$$\text{Per cent position} = \frac{100 (R_{ij} - 0.5)}{N_j} \quad \dots (3)$$

where,

R_{ij} – Rank given for i^{th} reasons by the j^{th} individual

N_j – Number of reasons ranked by j^{th} individual

The obtained percentage position for each rank was subsequently transformed into scores using Garrett's provided table. Participants were asked to prioritize opinions or reasons relevant to them based on their perceived importance. The assigned ranks

from each respondent were then converted into scores. Subsequently, the scores from individual respondents for each reason were summed and divided by the total number of respondents. The resulting mean scores for each reason were organized in descending order, and ranks were assigned accordingly.

RESULTS AND DISCUSSION

Factors Determining the Awareness of Farmers on Crop Diversification

The Logit model was used to assess the influence of various factors in determining farmers' awareness of crop diversification in agricultural risk management. The model was applied separately for five clusters: Cluster I, Cluster II, Cluster III, Cluster IV and Cluster V. The results are presented in Table 2.

The lower -2 log-likelihood values, specifically Cluster I (31.48), Cluster II (28.18), Cluster III (32.11), Cluster IV (33.35) and Cluster V (29.11), indicated that the logit models of all the clusters had a better fit with the data.

The estimates of Nagelkerke R^2 for five clusters, i.e., Cluster I (0.796), Cluster II (0.614), Cluster III (0.686), Cluster IV (0.918) and Cluster V (0.810) indicated that a reasonable amount of variation in the dependent variable is accounted for, by the considered independent variables of each model respectively.

Totally, eight independent variables were considered in the models. They were Age, Education, Size of the farm, Number of earners in the family, Number of agri extension meetings attended, Labour scarcity, Water scarcity and Ratio of non-farm income to farm income.

With regard to the variable 'Age', the MLE coefficients were significant and positively influencing in the models pertaining to clusters III and IV only. The odds ratio for Cluster III was 1.08 and for Cluster IV was 1.12. Hence it could be interpreted that, in the Cluster III scenario, when age increases by one unit, the odds of being aware of crop diversification increased by 1.08 times. In the Cluster IV scenario, when age increased by one unit, the odds of being aware of crop diversification increased by 1.12 times.

Table 2: Logistic Regression Estimates on the Factors Influencing Crop Diversification

Sl. No.	Variables	Cluster I			Cluster II			Cluster III			Cluster IV			Cluster V		
		MLE	Coefficient	Odds Ratio	P Values	MLE	Coefficient	Odds Ratio	P Values	MLE	Coefficient	Odds Ratio	P Values	MLE	Coefficient	Odds Ratio
1	Age	0.289		1.24	0.154	0.056		1.406	0.119	0.412***		1.081	0.009	0.508*		1.120
2	Education (Years of Schooling)	0.562***		2.158	0.008	0.489***		1.942	0.003	0.616**		1.148	0.016	0.884***		2.158
3	Size of Farm (Acres)	0.604*		1.904	0.091	0.284*		1.889	0.088	0.551*		1.010	0.068	0.712**		1.911
4	Number of Earners in the Family	-0.480		0.586	0.112	-0.304*		0.784	0.086	-0.409		0.616	0.422	0.224**		0.618
5	Number of Agri Extension Meetings Attended	0.846***		1.996	0.014	0.912**		2.416	0.029	0.994***		2.219	0.005	1.009**		2.509
6	Labour Scarcity (Yes or No)	0.881**		0.908	0.037	1.012		1.581	0.141	0.689		1.185	1.125	1.119***		1.109
7	Water Scarcity (Yes or No)	0.311**		1.714	0.049	0.198***		2.624	0.009	0.484**		1.084	0.037	0.298		0.643
8	Ratio of Other Income to Farm Income	-0.238		0.868	0.342	-0.114		0.346	0.124	0.112		0.962	0.762	0.265		0.579
	Constant/Intercept	4.258		594.312	0.089	5.186		629.102	0.098	5.146		640.516	0.109	5.914		709.181
	Nagelkerke R ²		0.796				0.614				0.686				0.918	
	-2 Log likelihood		31.478				28.184				32.106				33.346	

*** significant at 1 % level of probability; ** significant at 5 % level of probability; * significant at 10 % level of probability.

As far as the variable 'Education' is concerned, the MLE coefficients are significant and positively influencing in all five clusters. When education of the farmer increased by one year, the odds of being aware of the concept of crop diversification increased by 2.16 times in Cluster I, 1.94 times in Cluster II, 1.15 times in Cluster III, 2.16 times in Cluster IV and 1.49 times in Cluster V. It is imperative to note that, the education level of farmers seemed to play a vital role on the degree of awareness of the farming community on the importance of crop diversification in risk mitigation.

With regard to the factor 'Size of the farm', the MLE coefficients are significant and positively influencing Clusters I, II, III and IV. In the model pertaining to Cluster V, the MLE co-efficient was insignificant. In the Cluster I scenario, when the size of the farm increased by one unit, the odds of being aware of crop diversification increased by 1.9 times in Cluster I, 1.89 times in Cluster II, 1.01 times in Cluster III and 1.91 times in Cluster IV. It is evident from the results that the size of the farm definitely impacted the degree of awareness of farmers on the merits of crop diversification. This might be because of the reason that large farmers are comparatively in need of more alternatives and newer options to keep up their farm profit.

The variable 'Number of earners in the family' did not seem to play a significant role in determining the degree of awareness of crop diversification. The MLE coefficients were significant for only two clusters, viz., Cluster II and IV. The influence was negative with Cluster II and positive with Cluster IV. The interpretations were inconclusive in nature and might be ignored.

With regard to the variable, 'Number of agri extension meetings attended,' the estimated MLE coefficients of all five models were positively significant. The variable positively influenced the awareness of crop diversification in all the five cluster scenarios. In the Cluster I farming scenario, one unit increase in the 'Number of agri extension meetings attended', increased the odds of farmers being aware of the crop diversification concept by 2.0 times, 2.42 times in Cluster II, 2.22 times in Cluster III, 2.51 times in Cluster IV and 2.18 times in Cluster V. It is evident from the results that this variable was one among the influencing factors

capable of altering the degree awareness of farmers on the merits of crop diversification.

In the case of the variable 'Labour scarcity', the MLE coefficients of the models were significant for Clusters I, IV and V. The factors had a positive influence over the dependent variable in all the above three clusters. In the preferred farming scenario, if a farmer happened to experience labour scarcity, the odds of being aware of the concept of crop diversification would increase by 0.91 times in Cluster I, 1.12 times in Cluster IV and 1.05 times in Cluster V. The variable labour scarcity also seemed to influence the degree of awareness on crop diversification to a larger extent. Seeking alternatives and newer thoughts are common when there is a constraint. It could be interpreted that labour scarcity, like constraints, had induced farmers to search and make themselves aware of concepts like crop diversification.

With regard to the variable 'Water scarcity', the MLE coefficients were significant for Clusters I, II, III and V. The variable is capable of positively influencing the degree of awareness of farmers on crop diversification in the context of risk mitigation. In the above-said cluster scenarios, if a farmer encountered the problem of water scarcity, the odds of the farmer being aware of the concept of crop diversification increased by 1.71 times in Cluster I, 2.62 times in Cluster II, 1.08 times in Cluster III and 1.09 times in Cluster V. As like labour scarcity, water scarcity also influenced the degree of awareness on crop diversity. This could be interpreted with the same logic as discussed in the previous paragraph. The MLE coefficients pertaining to the variable 'Ratio of non-farm income to farm income' are not statistically significant to clusters I, II, III and IV. It is significant in Cluster V alone. It could be understood that the variable need not be given much importance since it is uninterpretable with the majority of clusters under discussion.

Major Inferences Derived Out of Logit Analyses

- ♦ The variables Education, Size of the farm, Number of agri extension meetings attended by farmers, Labour scarcity and Water scarcity were capable of positively influencing the farmers' degree of awareness of the concept

of crop diversification. Also, these findings of Logit analysis were in similar lines to the conclusions of studies conducted by Arthi *et al.* (2016), Onyeneke (2017), Majumder *et al.* (2019) and Amirthalingam *et al.* (2020). Hence, it could be interpreted that the agri-extension agencies could earnestly attempt to improve the awareness level of farmers on crop diversification by conducting training and educating them.

- ♦ The variable 'Age', which could be considered as a proxy for the experience of the farmer, was also capable of having a positive influence over the awareness of crop diversification but on a milder note than the variables discussed above.
- ♦ The variables 'Number of earners in the family' and 'Ratio of non-farm income to farm income' did not exhibit any significant influence over the degree of awareness of the crop diversification concept.

Reasons for Non-Adoption of Crop Diversification

Cluster-wise Garrett rank analyses were undertaken

to prioritize the primary factors contributing to the non-adoption of crop diversification. The reasons were identified and listed separately for each cluster, based on the opinions obtained from respective farmers during the pilot survey. The reasons were ranked by the farmers of respective clusters and are presented in Table 3.

Cluster I

With regard to Cluster I, the primary and most important reason for non-adoption of crop diversification, as ranked by the respondents, was 'Fear of production failure', followed by other reasons, viz., 'Lack of awareness on suitable alternative crops', 'Fear due to marketing risk' and 'Fear due to financial risk'. The farmers of this cluster are mostly accustomed to growing only paddy as a mono-crop. Every farmer might have a specific marketing channel in which they are comfortable. It could be understood that the production, technical and marketing risks dominate more in farmers' minds and might have tuned the farmer's attitude to be unmindful of the risks due to cyclones and agro-climate devastations.

Table 3: Cluster-wise Major Reasons for Non-adoption of Crop Diversification by Farmers

Sl. No.	Clusters	Reasons	Garrett Score	Rank
1	Cluster I	♦ Fear of production failure	79.56	I
		♦ Lack of awareness of suitable alternative crops	68.22	II
		♦ Fear due to marketing risk	51.43	III
		♦ Fear due to financial risk	49.47	IV
2	Cluster II	♦ Fear of production failure	77.49	I
		♦ Lack of financial backup to venture into a new system	69.12	II
		♦ Lack of awareness of suitable alternative crops	60.44	III
		♦ Fear due to marketing risk	58.51	IV
3	Cluster III	♦ Fear of production failure	86.33	I
		♦ More attached to the conventional wisdom on cropping pattern	72.89	II
		♦ Lack of awareness of suitable alternative crops	70.16	III
		♦ Fear due to marketing risk	61.44	IV
4	Cluster IV	♦ Present system is more remunerative	88.65	I
		♦ Unique soil type suitable for cashew	81.42	II
		♦ Highly experienced with existing cropping pattern	69.72	III
		♦ Ease in the marketing of present produces	58.56	IV
5	Cluster V	♦ Sense of frustration due to scarcity of resources	79.42	I
		♦ Lack of awareness of suitable alternative crops	63.44	II
		♦ Fear due to financial risk	61.56	III
		♦ Fear due to marketing risk	46.41	IV

Cluster II

In this cluster also, the foremost reason quoted for non-adoption of crop diversification was 'Fear of production failure'. The second reason was 'Lack of financial back-up to venture into the new system'. This reason might have been quoted since the farm income was comparatively lower in this cluster. The third reason was the 'Lack of awareness on suitable alternative crops' followed fourthly by 'Fear due to marketing risks'.

Cluster III

With regard to Cluster III, the reasons quoted for non-adoption were firstly, 'Fear of production failure', followed by 'More attached with conventional wisdom on cropping pattern', 'Lack of awareness on suitable alternative crops' and 'Fear due to marketing risk'. This is a cluster where paddy is grown in three seasons a year. Paddy-Paddy-Paddy is the typical cropping pattern of this cluster. The first reason for non-adoption was similar to the previous two clusters. As far as the second reason, 'More attachment with the conventional wisdom on cropping pattern' is concerned, it might be quoted since farmers are more accustomed to paddy cultivation, which they consider as respectful and even sacred.

Cluster IV

As far as Cluster IV is concerned, it is a cluster where perennial Cashew is grown as mono-crop. The first reason quoted for non-adoption of crop diversification was 'Present system is more remunerative', followed by 'Unique soil type suitable for cashew', 'Highly experienced with existing cropping system' and 'Ease in the marketing of present produces'. Though the contended attitude of farmers is welcome, the lessons learnt from cyclone 'Thane' have given a serious indication that is growing perennial as mono-crop would reduce the resilience of farmers during major cyclonic havoc. Hence, in the long-term perspective, mixing annual with perennial is inevitable to enhance the resilience of farmers.

Cluster V

Cluster V is the most disadvantageous cluster, where paddy is grown in only one season, that too

with the help of water from the Mettur reservoir and rainfall. The foremost reason for non-adoption of crop diversification as ranked by farmers of the cluster was 'Sense of frustration due to scarcity of resources'. Scarcity of water always exists in this cluster since most of the villages of this cluster fall in the tail-end region of the Cauvery River. Labour scarcity is also prevalent in this cluster. The local labours intend to migrate since job availability is much seasonal in this region. The second reason quoted was 'Lack of awareness on suitable alternative crops' followed by the reasons, 'Fear due to financial risk' and 'Fear due to marketing risk'.

Major Inferences Drawn out of Garrett Analyses

- ♦ With regard to Cluster I, Cluster II and Cluster III, the major reason identified for non-adoption of crop diversification was 'Fear of production failure'. Farmers were hesitant to try a new crop and its production technology.
- ♦ As far as Cluster IV is concerned, though farmers are contended with what they cultivate (Cashew), mixing annually seems to be inevitable for enhancing the resilience of farmers during major cyclonic havoc.
- ♦ Cluster V is the most disadvantageous cluster since it is located in the tail-end region of the Cauvery River. A sense of frustration prevails among these farmers, and they are not prepared at the mind level to venture into alternative cropping systems. This finding is in line with the results of the Logit analysis. As per Logit analysis, the factors of Labour scarcity and Water scarcity both seemed to influence significantly the farmer's degree of awareness of crop diversification in Cluster V.

CONCLUSION

In the study area, most of the farmers either cultivate annuals or perennials as monocrop. Monocropping would reduce the resilience of farmers. A diversified crop plan would be ideal for mitigating risk in cyclone-prone areas. The Logit analyses indicated that the awareness of farmers on such diversifications was positively influenced by agri-extension activities, and Garrett analyses revealed that by and large, the reason "Fear of production failure" was the principal cause for

non-adoption of crop diversification. Hence, by utilizing the available Governmental extension machinery, an earnest attempt could be made to enhance the awareness level of crop diversification by conducting training and educating them on the production techniques of suitable alternative crops.

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