Smallholders' diversification in Pauh Sub District Padang City West Sumatera Indonesia

AS Utami¹, R Azhari¹, I W Syarfi¹
¹ Socio economic Department, Universitas Andalas, Padang -Indonesia

Corresponding author: ami_sukma@yahoo.com

Abstract. Plantation farming is an economic activities with high risks and uncertainties (income fluctuations between production cycles or even between years is quite high) therefore the motives of farmers for diversification are often more oriented towards stabilizing income than maximizing income. Production diversification is one of the effective adaptation methods to reduce the risk of production due to climate change and is conducive to supporting the development of local resource-based processing industries. Therefore, this study aims to analyze the model of plantation diversification in Pauh Sub Distric, Padang city. The method of the study is qualitative method. The respondents are the plantation smallholder who are diversifying their farm in Pauh sub-Distric. The study found that, there are four models of diversification in Pauh District; Plantation crop with horticultural crops diversification, Plantation crop with food crop diversification, Plantation crop with livestock diversification, and Combination. The level of diversity in Pauh is between 0.2 to 0.4. The lowest level of diversity is 0.237, while the highest level is 0.434.

Keyword: Sustainable Agriculture, Rural Economy, Sub Urban

1. Background of Study

Many farmers in tropical and temperate countries survive by managing a mix of different crops and/or animals. The best known form of mixed farming is when crop residues are used to feed the animals and the excreta from the animals are used as nutrients for the crops. Other forms of mixing take place where grazing under fruit-trees keeps the grass short, or where manure from pigs is used to "feed" the fish pond. Traditionally, a wide variety of mixed farming systems has been used worldwide. These systems are essential for the livelihood of farmers and for the production of food and other commodities for the cities and export markets. Even many highly specialized crop and livestock systems in developed and developing countries are rediscovering the advantages of mixed farming. For example, specialized industrial pig and poultry farmers are banned from modern countries such as Singapore, and in western Europe they are forced to exchange their dung surpluses with crop farmers. Moreover, the essence of many modern organic farming systems lies in the mixing of crops and animals [1].

In Asia, the integration of livestock, fish and crops has proved to be a sustainable system through centuries of experience. In China, for example, the integration of fishpond production with ducks, geese, chickens, sheep, cattle or pigs increased fish production by 2 to 3.9 times [1], while there were added ecological and economic benefits of fish utilizing animal wastes. Environmentally sound integration is ensured where livestock droppings and feed waste can be poured directly into the pond to constitute feed for fish and zooplankton. Livestock manure can be used to fertilize grass or other...
plant growth that can also constitute feed for fish. Vegetables can be irrigated from the fishponds, and their residues and by-products can be used for feeding livestock [2].

Low income and poverty are the main problems in economic development in developing countries, especially Indonesia. Thus, in the economic development goals, the two things are always stated together so that they become one sentence, namely increasing national income and reducing poverty [3]. Income inequality in rural areas is influenced by the condition of local agroecosystems [4]. Low productivity areas have a reciprocal relationship with poverty, both as a cause and as a result. Therefore, an area with a low level of productivity can lead to poor communities. Likewise, the inability of the community to manage resources has resulted in the region being poor. Household income structure in the countryside varies depending on the diversity of agricultural resources.

Farming includes economic activities with high risk and uncertainty (income fluctuations between production cycles or even between years are quite high). Therefore the motives of farmers for diversification are often more oriented towards stabilizing income than maximizing income [5]. Diversification began to evolve in Indonesia since PELITA II (Pembangunan Lima Tahun) in 1974. This program intended to enhance intensification and extensification program with aim to strengthening food self-sufficiency. This program was intended to integrate horticulture with rice cultivation. However during the implementation of PELITA II, there were a number of inconsistencies in policy and development as a result of rice politics that were dominant. Hence, the vision of diversification never existed [6].

Diversification can reduce the probability of total crop failure in farm and enable the farmer use a greater variety of crops or vegetable for daily diet. Furthermore, diversification may reduce or avoid food shortage. By doing diversification, it also may reduce labor peaks and may lead to a labor requirement at farm household level. Finally, an appropriate crop rotation system may stabilize the yields and contribute to the conservation of soil fertility [7].

Farm diversification is one of the main programs of agricultural development in addition to extensification, intensification and rehabilitation programs. The development program for farming diversification in rice fields is associated with efforts to increase income, expand employment opportunities and reduce poverty, is one of the right strategy choices. Since Pelita I (1974-1978), the government has developed a farming diversification program, but in its development, the program has not shown the expected performance [6].

For Indonesia, diversification of production is very urgent. Production diversification is one of the effective adaptation methods to reduce the risk of production due to climate change and is conducive to supporting the development of local resource-based processing industries. On the consumption side, diversification broadens the spectrum of choices and is conducive to supporting the realization of food security. In short, diversification of food based on local food ingredients is conducive to supporting the stability of food security and increasing the flexibility of the system so that it can be seen as one of the pillars of strengthening food security. Therefore, diversification acceleration as mandated in Perpres No. 22 of 2009 must be realized.

Pauh district in Padang City, West Sumatera with land area of 146.29 km2 is the second widest district in the city of Padang after Koto Tengah district (232.25 km2) and district where Andalas University was built. Land in Pauh district is used mainly for Forests (protected and community forests) and mix garden covering 488 hectare [8]. In Pauh district, the protected and communal forest areas are very dominant in this district, which covers 82% of the total area of the district, the remaining most of the area is paddy fields and mix gardens.

Farmers in Pauh district generally conduct diversification for their farms. In one household, farmers cultivate more than two types of plants. They cultivate vegetable crops in their home garden.

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1 PELITA (Pembangunan Lima Tahun or Five Years Development) was a government program enhanced the people's lives by increasing production and incomes and changed the colonial economic structure into the structure of the national economy with the opening business opportunities across the economic and social field (Act 85 of 1958).
and cultivate tree crops such as mangosteen (*Garcinia mangostana*) and jengkol (*Archidendron pauciflorum*) in communal forests. There are also farmers who combine tree crop and vegetable crop with food crop (Rice) and farmers who combine their tree crop and vegetable crop with livestock such as cattle, chickens and goats. Various model of diversification are carried out by farmers in Pauh district to increase household income. Thus, the aim of the research is to describe the model of diversification of in Pauh District?.

2. Literature Review

A considerable amount of literature has been published on diversification. One of them is Robison & Barry [9] argue that diversification means to develope a larger number of crops or enterprises-mix in farm. It may be the response of subsistence farmers to risk arising from climatic, biotic, economic or seasonal factors. These uncertainties effect the variable returns (farm income) to decision farmers make in particular year. In this current study, we define diversification based on Robinson & Barry definition of diversification. We selected diversification farmers that produce more than one or two crops in their farm, whether in the same or different area, within a year.

Diversification according to Ilber [10], involve several of resources from production factor such as land, labor and capital which are previously committed to conventional farming activities. Ilbery also argues that regarding to diversification of farm production, it can be good solution for decline of commodity price by adding value to existing commodity export diversifying the same product or promoting. Moreover, diversification can be either structural, including activities oriented outward from the farm towards the public, or agricultural, including activities focused on farming and the various types of farm work (but which are different from traditional farming). While Hoeper [7] said that diversification of agriculture is way for increasing food security by cultivating several different crop. Due to this condition, horticultural production can improve the yield in long run.

Limbong [11] compared the advantages of monocropping and diversification, these are: the income of diversification is greater than monocropping and labor requirement in diversification farm is greater than monoculture per hectare due to maintenance of farm diversification is more intensive than the monoculture farming. Finally, the cost production of diversification farming is greater than the cost of monocropping.

Diversification should be followed by intensification of agriculture in order to improve food security at household level. Intensification means using more capital intensive inputs or work more on weeding, observing etc. Under this condition production technique will show result in long term. The low input strategy is considered in order to increase the yield of crop production. There is no contradiction in “intensifying crop production by diversification” [7].

According to Barbieri and Mahoney [12], there are seven different types of diversification, these are: including non-traditional crops, livestock, and/or practices; alternative marketing schemes; tourism and recreation; lease and rental of resources; contract machine services; value-added processing; and preservation, education and consulting services.

At the beginning, the reason of farmers to diversify their farm production was to fill family basic needs. However, it began to growth over time, farmer more concern to increase their income through diversification. Diversification can reduce crop failure, may reduce labor peaks and may lead to a labor requirement at farm household level and the most important is to increase farm income. In terms of micro level, it is directed to fill demand with goal to reach production surplus [7].

In Indonesia, there are two types of agricultural diversification. Horizontal diversification attempts to replace or improve the agricultural monoculture towards multicultural crops. It is on farm level, farmers demanded the freedom to allocate the available resources optimally in accordance with the existing conditions. Vertical diversification is effort to promote industrial agricultural product processing industry. It is primarily intended to increase the value added through processing and product quality improvement. Diversification is required in a linkage other activities both farm level and institutional level, while the regional diversification needs to be based on the principle of comparative advantage [13].
Some studies have revealed about factors influencing farmers to diversify their farm, these are: (1) sustainable income, (2) availability of fertilizers and pesticides that are easy to obtain, (4) an appropriate soil conditions and climate / weather, and (5) reduce pest in the farm [14]. The other reason is for reduce production risk. Due to this condition, there are several factors that need to be considered for choosing cropping pattern such price of product, input and availability of resources.

Hodgkin also pointed to some factors that influence farmers to maintain diversity such economic, ecological, political, social and cultural factors. These finding are consistent with those other studies and revealed that population structure and natural selection as an additional factors, come from surrounding environment that important and may themselves be influenced by farmer [15].

In most recent studies, diversity could determine by some factors. One of study from [16] Rehima et al. used several variables to determine factors contributing to diversification by using Ordinary Least Square method such characteristic of sample (i.e age, gender, education etc) and the others variable such farms size, labor and also market access. They were some significant variables that contribute to diversity such gender, education that had a positive association with the level of diversification. Contrary to their expectation, the coefficient of trade experience was negatively related to diversification. Furthermore, the effect of social organizations had to the probability of crop diversification. The last is land size that significantly and positively affected the crop diversification decision of the households.

In line with this study, another study of Benin et al. [17], defined some variables to determine factors of diversity such household characteristics; age, sex of household head, education, household size, oxen ownership, exogenous income. They also adding with farm characteristics; slope of farmland, erosion of farm, fertility of farm, irrigation, farm size, farm fragmentation, number of farm plots, distance from house to farm. The result of this study is socio-demographic characteristics of the household such as the age and sex of the household head, the education of its members, and its size have no significant relation to the diversity. However, farm size have significant influence on diversity associated with greater diversity within as well as evenness in the extent of soil erosion on the. The last is market-related factors have effects to diversity that depend on both the measurement of the factor and the crop.

In this study we used Margalef's index. Although it do not include any component of evenness, however it easy to maintain and still appropriate used in this study. This index is attempts to estimate species richness independently of the sample size. The index will be independent of the number of individuals in the sample only if the relationship between $S$ (or $S - 1$) and $\ln(N)$ or $\sqrt{N}$ is linear. The indices are:

$$I_{\text{Margalef}} = \frac{(S - 1)}{\ln(N)}$$
$$I_{\text{Menhinick}} = \frac{S}{\sqrt{N}}$$

Diversification existed since long time ago in Indonesia, as we stated before in introduction part. It began with home garden produced by woman. Arumsari & Rini [18] argue that in home garden, rural women grow vegetables that are important to household nutrition. Women's roles in crop production are expanding: the out-migration of young men from rural areas in some regions has led to permanent changes in women's responsibilities and tasks.

World Bank [19] in its recent sourcebook on gender and agriculture points out that rural women and men play important roles in biodiversity management. Women and men, depending on their cultural and social backgrounds, perform different roles and have varying responsibilities in agriculture – in crop production as well as crop management. Hence, they have different needs, priorities, and knowledge about diverse crops, plants, and animals. Women are typically involved in the selection, improvement, and adaptation of local plant varieties, as well as seed exchange, management, and saving. They often keep home gardens where they grow traditional varieties of vegetables, herbs, and spices selected for their nutritious, medicinal, and culinary advantages.
In 1974, Indonesian government promoted agricultural diversification through Pelita II and Pelita IV, in order to increase the supply of various agricultural commodities by improving and expanding commodity diversification for smallholder farming. This program intended to increase the diversity of commodities, especially cultivated horticultural and farming combined with existing farming [20]. Furthermore, the current agricultural diversification program in Indonesia is UPSUS for food self-sufficiency that has been implemented since 2015-2017. This program is a government effort to increase the production of rice, corn, soybeans, beef, sugar cane, chili and shallots so that Indonesia can achieve food self-sufficiency.

3. Methodology
This research was conducted with a quantitative approach. The design of the study is a case study, with a unit of analysis of farmers whose trying to diversify their plantation crops. This research analyzed the model of diversification of garden plants by the people. The research was conducted in Pauh Subdistrict, Padang City. The research was conducted from June to August 2018. Data collected in this study are primary and secondary data. Primary data is collected by Rapid Rural Appraisal (RRA) method, Observation, and in-depth interviews. While the secondary data was collected from some literatures. The respondents in this study are 30 farmers in Pauh Sub District, Padang City, West Sumatera, Indonesia. We visited the farm in Pauh and interviewed the farmer that we saw in the farm, then we asked them to inform about the other farmer who did diversification farming. The result of the study was analysed by descriptive analysis.

4. Result and Discussion
4.1. Research Area Description
Pauh district is one of eleven district in Padang city. It has altitude 10 – 1600 above the sea level. Pauh district have 0058’ longitude and 100021’11’ latitude. The temperate range is between 22°C to 31,7°C. The total area of Pauh sub-district is 146,29 km². This sub-district has topography state area which is forest area. Protected forest areas and community forests are very dominant in this sub-district, which covers 82% of the total area of the sub-district, and the rest are rice fields, plantation and settlement. The area of protected forest is 10.103 ha, while the communal forest is 1.895 ha. The area of rice paddy field is 1.098 ha and area of plantation is 488 ha [8].

Figure 1. Maps of Pauh Sub District
We interviewed 30 farmers and more than 40% are in age between 41 to 50 years old. This number followed by age between 51 to 60 years old with 30%. The samples dominated by female with percentage of 63%. More than 50% of the farmers finished their study in elementary school. Furthermore, 43% of the farmers finished their study in high school. Most of the farmers has experience in horticultural farming for 10 to 25 years. Only 18 % of the farmers are having experience more than 26 years.

Most of the farmers in Pauh district are having land size between 0,1 hectare to 0,5 hectare dominated by woman. In Pauh district, the agricultural lands are using communal land. This land is belongs to the tribes in Pauh district. The leader of the tribe distributes the land to each family. The owner of the land is the woman. The distributions of the land depend on the number of woman in the family. The woman will get 2 types of communal land, the first is land that they got from their mother. It belongs to the family called *Pusako Tinggi*. The second called *Tanah Kaum* belongs to the tribe, however, men could also be used *Tanah Kaum*.

4.2 Farmers’ Motivation for diversifying their farm

The economic factor is the main factor that influence farmer for choosing their cropping model. They can answer more than one factor for choosing of their cropping model. All of them chooses economic factor as main factor for choosing diversification farming. Most of them said that it can increase their income, sustainable income all over the year and also as capital source for the next farming. By doing diversification, the farmer can get additional income while they are waiting for their main crops harvested. The finding of current study is consistent with one of Barbieri & Mahoney [12]. result that the reasons of farmer to diversify their horticultural production are to generate additional farm income and to continue farming, and to enhance their own and families quality of life.

There are several farmers’ motivation in diversification farming. Medhurst and Segrave [22]. in their study stated a principal aim was to investigate the drivers influencing the decision to diversify and can be classified into three segments which are financial, family circumstances and lifestyle. While both family and lifestyle incorporate elements of financial drivers within them, the financial components were not necessarily the primary drivers and, therefore, further segmentation was justified. Maintaining farm viability by increasing income is the most commonly mentioned driver for diversification.

![Figure 2. Percentage of Farmers Motivation on Diversification](image-url)
them finished their study in the high school. In other study of Rehima [16], stated that education is contributing to the farmers’ capital enhances the ability to hold new production techniques more rapidly, to seek new information on technology and to meet more complex management requirements of crop diversification.

The last factor is environmental factor, only 6 % of the respondent answered this factor. These farmers said that, diversification can reduce the pest during the production period and it can increase their soil nutrition (Figure 2). This finding further support the idea from Sidle et al. [23] that diversification has an impact on environment. Fruits diversify with vegetable grown in upland have limit soil erosion and land degradation.

4.3 Diversification Model in Pauh District

The farmer in Pauh produces plantation crops, horticultural crops and food crops. They produced horticultural crops such as cucumber (Cucumis sativus L), beans (Vigna unguiculata ssp), chilly (Capsicum annuum), chives (Allium schoenoprasum). The plantation crops cultivated in Pah district such Durian (Durio zibethinus), Cinamon (Cinnamomum verum), Mangosteen (Garcinia mangostana) etc. The average production of food crop such as rice in Pauh district is 5,55 tons / ha and cassava is 17.47 tons / ha. The vegetable crop such as Kale (Brassica oleracea var. sabellica) production is the most production in Pauh district, reaching 2,14 ton/ha, for the second most is chilly (Capsicum frutescens), with a production of 2,12 ton/ha. For most plantation commodities such as Durian (Durio zibethinus), with the production is 7.26 ton/ ha tons, the second with a production of 66.05 ton/ha is Rambutan (Nephelium lappaceum). The livestock in Pauh district are: Cattle, Goat, Sheep and Chicken. The most livestock population is cattle with population of 2782 cattle in Pauh [8].

We calculate the level of diversification in Pauh. According to Margalefs’ formula, level of diversity in Pauh is between 0.2 to 0.4 (Number of plan/ Total area). The lowest level of diversity is 0.237 Number of plan/Total area, while the highest level is 0.434 Number of plan/ Total Area (Figure 3). This level of diversity in Pauh District is still low. Most of the farmer cultivated three of four agricultural product commercially in their farm even though they can cultivated more in their land.

![Figure 3. Percentage of Level of Diversity](image)

Farmers diversify their farm with various models. Based on the interview of the farmer, we found four types of diversification farming in Pauh district as follow;

4.3.1 Tree crop with vegetable crop diversification,

In this type farmer diversify tree crop such as Mangosteen (Garcinia mangostana), Durian (Durio zibethinus), or Rambutan (Nephelium lappaceum) and coconut tree with horticultural crop such as cucumber (Cucumis sativus L), Kale (Brassica oleracea var. sabellica) or Beans (Vigna unguiculata ssp). The farmer cultivated the tree crops in the communal land (communal forest) and
cultivated the horticultural crop in their home garden. The other model is the tree crops and the horticultural crops planted side by side.

![Figure 4. Tree crop with vegetable crop diversification](image)

4.3.2 Tree crop with food crop diversification,

Rice production in Pauh District is one of the largest production in Padang city. Most of the farmer cultivates their Paddy farm near the settlement and cultivates the tree crop such as Coconut tree (*Cocos nucifera*), Rambutan (*Nephelium lappaceum*), Mangosteen (*Garcinia mangostana*) beside the Paddy farm. The other model is the farmer cultivates the tree crop in the communal forest and cultivate the Rice (*Oryza sativa*) near their settlement.

Cassava is the one of the most widely grown agricultural production in Pauh district. As you can see in the picture below, the cassava cultivates around the tree crop such as coconut tree (*Cocos nucifera*), Rubber tree (*Hevea brasiliensis*) and Jengkol (*Archidendron pauciflorum*)

![Figure 5. Tree crop with food crop in Pauh District](image)

4.3.3 Tree crop with livestock diversification,

In this type the tree crop and livestock are cultivate in the communal forest. The livestock such Cattle and Goat are cultivated in the middle of their tree crop. However some of the farmers cultivate their livestock such as chicken and goat near their settlement.
4.3.4 Combination
This type is the combination of three model above, the farmer cultivate the Paddy, tree crop and livestock at the same time. Some farmers cultivate Paddy (*Oriza Sativa*) side by side with tree crop such (*Nephelium lappaceum*, Manggosteen (*Garcinia mangostana*) and Chicken near the settlement. Some farmers cultivated Paddy side by side with horticultural crop and cultivate tree crop and livestock in the communal forest.

4.4. Discussion
The economic factor is the main factor that influence farmer for choosing their cropping pattern. Both farmers, monocropping and diversification farmers, have economic reasons to choose their cropping systems. Although the specific factors are different each other, for example monocropping farmer answered that price of the orange have strong influence for farmer to do specialization in one crop. The diversification farmers, intend to choose sustain income all over the year. By doing diversification, the farmer can get additional income while they are waiting for their main crops harvested. The finding of current study is consistent with one of Barbieri & Mahoney [12] result that the reasons of farmer to diversify their horticultural production are to generate additional farm income and to continue farming, and to enhance their own and families quality of life.

Environmental factor has lower percentage from all the factors, 6% of the farmer answer environmental factors such diversification can reduce pest in farm and also enrich nutrients in the soil. This finding further support the idea from Sidle et al [22] that diversification has an impact on environment. Fruits diversify with vegetable grown in upland have limit soil erosion and land degradation.

In terms of their social background, these farmers have more than 25 years of experience in horticultural farming. Furthermore, some of them finished their study in the high school. Although in this study, education is not one of significant variable for diversification, but it could be influence farmer for more care about environment. In other study of Rehima [16], stated that education is contributing to the farmers’ capital enhances the ability to hold new production techniques more rapidly, to seek new information on technology and to meet more complex management requirements of crop diversification.

Diversified systems consist of components such as crops and livestock that co-exist independently from each other. In particular, farmers can have pigs, dairy and crops as quite independent units. In this case the mixing of crops and livestock primarily serves to minimize risk and not to recycle resources [1]. Base on the result of this study, there are several types of diversification in Pauh Sub district. The types is almost the same with diversification in Asia. According to FAO [1] Grazing of
livestock under plantation trees such as rubber, oil palm or coconut is a form of crop-livestock integration that is often found in Southeast Asia. Experiments in Malaysia with cattle and goats under oil palm showed better oil palm bunch harvest and comparable results were found where goats fed under rubber trees. In rubber and oil palm plantations in Malaysia, the integration of livestock to utilize the vegetative ground cover under the tree canopy increased overall production and saved up to 40 percent of the cost of weed control. Similarly, sheep helped to control weeds in sugar cane fields in Colombia. This suppressed the costs of herbicides, reduced the cost of weed control by half and provided additional income from meat production.

Based on the result of the study, the diversification level in Pauh Sub District is still low (<0.5 total plan/total area). Compared to other study of Joshi et.al [23], diversity permits South Asian farmers to cultivate variety of crops, rear different species of livestock and catch wide range of fish species from various sources. Level of diversity for South Asia was 0.64 in triennium ending (TE) 1999-2000, up from 0.59 in TE 1981-82. This shows that South Asia is gradually diversifying its crop sector in favor of high value commodities, especially fruits, vegetables. Among countries, Bangladesh, Bhutan and Nepal show less diversity as compared to other countries. Bangladesh has specialized in rice. More than three-fourths of the area in the country is under rice. But the remaining one-fourth area is highly diversified, which was a result of some policy initiatives taken-up in different plan periods.

Crop diversification can be a useful means to increase crop output under different situations. Crop diversification can be approached in two ways. The main form and the commonly understood concept is the addition of more crops to the existing cropping system, which could be referred to as horizontal diversification. For instance, cultivation of field crops in rice fields or growing various types of other crops in uplands have been defined as crop diversification. The other type of crop diversification is vertical crop diversification, in which various other downstream activities are undertaken. This could be illustrated by using any crop species, which could be refined to manufactured products, such as fruits, which are canned or manufactured into juices or syrups as the case may be. There are terms such as “crop substitution” and “crop adjustment”. It is necessary to indicate here that crop substitution and adjustment are linked to the main concept of crop diversification and are strategies often used to maximize profit of growing varieties of crops. The level of diversification will also be different in various countries. Diversification at farm level will involve growing of several crops for achieving self-sufficiency, but it may be a totally different approach at the national level. Crop diversification at national level will demand more resources and require selection and management of a specific crop or a group of crops sold freshly or value added to achieve higher profits [24].

5. Conclusion
Based on the results above it can be conclude that there are 4 types of diversification in Pauh District, namely: Tree crop with horticultural crops diversification, Tree crop with food crop diversification, Tree crop with livestock diversification, and Combination. The level of diversity in Pauh is between 0.2 to 0.4. The lowest level of diversity is 0.237, while the highest level is 0.434. This number is still low compared to level of farm diversity in South Asia. It is suggested that the farmer should maintain their farm diversification in order to obtain the advantages of crop diversification by changing from very simple forms of crop rotations, to intensive systems such as relay cropping and intercropping or specialization by diversifying into various crops, where the output and processing etc., could be different.

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