

# Analysis of Sedimentation as Implications of Beach Accretion using Spatial Analysis in the Coastal Area of Banyuasin South Sumatra, Indonesia

*by* Muhammad Hendri

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### **Analysis of Sedimentation as Implications of Beach Accretion using Spatial Analysis in the Coastal Area of Banyuasin South Sumatra, Indonesia**

*Analisis Sedimentasi Sebagai Implikasi Terjadinya Akresi Pantai Menggunakan Analisis Spasial di Pesisir Banyuasin Sumatera Selatan Indonesia*

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#### **ABSTRAK**

Penelitian ini dilakukan di wilayah pesisir Banyuasin (WPB), lokasi penelitian dianggap memiliki keragaman kelas pengendapan yang berasal dari proses fluvial dan marin. Tujuan penelitian untuk menentukan perubahan morfologi wilayah pesisir terkait sedimentasi yang berada di WPB dan membuat pemetaan terkait parameter oseanografi, perubahan tutupan lahan dan identifikasi sebaran sedimentasi yang terjadi di WPB, dan faktor dominan yang mempengaruhi perubahan. Penelitian ini menggunakan metode interpretasi citra dan pengambilan data sedimen menggunakan alat sedimen trap, untuk mengetahui terjadinya akresi dan abrasi. Hasil penelitian menunjukkan telah terjadi perubahan lingkungan berdasarkan analisis citra Landsat di WPB tepatnya pada Pulau Ekor Tikus (PET), Tg.Api-api, dan Sungai Bungin, yang dipengaruhi oleh konversi lahan, sedimentasi, dan arus pasut. Jadi telah terjadi perubahan lingkungan di WPB terutama pada lokasi muara Banyuasin (PET) dengan laju sedimentasi yang tinggi. Perubahan juga terjadi di Tg Api-api dan sungai Bungin, dengan faktor dominan adalah penurunan hutan mangrove (konversi lahan). Sehingga perlu dilakukan pengkajian lebih detil dan *time series* terkait mangrove dan dilakukan dengan lokasi yang lebih luas.

Kata kunci: pesisir Banyuasin, taman nasional sembilang, pulau “Ekor Tikus”

#### **ABSTRACT**

This study was conducted in the coastal area of Banyuasin (CAB) which was considered to have a variety of sedimentation classes originating from fluvial and marine processes. The study aimed to observe/determine changes in the morphology of coastal areas related to sedimentation in the CAB and to make maps related to oceanographic parameters, changes in the land cover and identification of the distribution of sedimentation occurring in the CAB, and the dominant factors influencing the change. This study used imagery

interpretation method and the sediment data collection used sediment traps to determine the occurrence of accretion and abrasion. The results of the study showed that there was a change in the environment based on the analysis of Landsat imagery, that have undergone changes are Ekor Tikus island (PET), Tg Api-api (TAA), and the Bungin River (SB), which are affected by the land conversion, sedimentation, and tidal currents. There has been an environmental change in the CAB, especially at the Banyuasin estuary (PET) with a high sedimentation rate. The changes also occurred in TAA and SB, with the dominant factor being the decline in mangrove forests. As a result, it is necessary to conduct a more detailed study and time series related to mangroves.

Keywords: coastal area of Banyuasin, Sembilang national park, "Ekor Tikus" island

## INTRODUCTION

The Coastal Area of Banyuasin (CAB) of South Sumatra has a unique ecosystem diversity, with the Sembilang National Park (SNP). SNP is a mangrove ecosystem that currently includes a unique ecosystem in the world having biodiversity and as a conservation area, a place for migratory birds from Siberia (Sagala & Lambok, 2019). In addition, the mangrove ecosystem is also used by humans as a producer of firewood, this is supported by (Scales et al., 2019) generally the pressure that occurs in the mangrove ecosystem related to the use of mangrove ecosystems and mangrove trees, namely the development of coastal cities, agriculture (aquaculture), use of firewood, charcoal and materials for construction, changes in the hydrological cycle, sea level rise and sedimentation (Mustafa et al., 2020) (Kathiresan, 2012). The decrease in the area of the mangrove ecosystem due to the agricultural activities, plantations, urbanization, and aquaculture has an impact on increasing the erosion and sedimentation in coastal waters and oceans (Wu & Qin, 2020) (Oh et al., 2017), in which the sedimentation can lead to changes in the morphology of coastal areas and aquatic bathymetry (Wang & Jun, 2018).

The problem of CAB is an area of sediment deposition (sedimentation) which has an interaction of two different water masses originating from large rivers and oceans (Bangka Strait), which then forms a delta and cape environment, this will then affect the distribution of sediment particle

size which reflects the fluidity factor and energy of precipitation (Thao et al., 2019) (Sklar & Leonard, 2017). The increase in accumulated sedimentation in the CAB is dominated by the presence of large rivers, namely the Musi, Telang, Lalan and Banyuasin rivers which carry sediment particles which then accumulate in the coastal area and are deposited in this location, if this continues it will result in disruption of shipping channel, so it is necessary to identify related sediment transport (Amos, 2020).

Previous study related to the distribution of sedimentation has not been widely carried out. A mathematical model that describes the distribution of river sediments during uneven movement in the structure has been developed, which is characteristic of this model. The distribution of sediment in rivers depends on the fraction (Arifjanov et al., 2019) (Castagno et al., 2021) analyzing grain size trends in sediments caused by storms along the core sediment transect originating from the estuary at Mattapoisett, Massachusetts, and also characterizing sorting trends and comparing sediment associated with the occurring storms. Furthermore (Attal, 2015) (Duy & Dinh, 2018) provided a relationship between land steepness and grain size distribution originating from higher ground locations and towards the fluvial sediment-dominated lowland locations, where the study sites were in the Feather River basin of Northern California, tonalite lithology, the roughness hillside sediment increases with increasing steepness of the hillside and the increasing rate of coastal erosion. This

method cannot be used in the CAB because the CAB is not upland and has no sloping topography.

The study related to the above sedimentation and land changes cannot be applied in the CAB, therefore it needed separate study related to the sedimentation. The novelty of this study is the location of the CAB which is a unique area with the presence of SNP. In addition, this study used an oceanographic parameter approach and a bathymetric survey to find out how the accumulation of morphological changes in the CAB. This study aimed to determine and map the changes in the morphology of the CAB related to the sedimentation and the dominant factors influencing the changes in the CAB.

## MATERIALS AND METHODS

### Study Area

The study was carried out in the CAB by observing, measuring and taking sediment samples which were analyzed in the laboratory to obtain the value of sedimentation rate and basic sediment types. The locations for taking and measuring field parameters (Figure 1).

Field work analysis using current meter equipment to measure current direction and velocity. Handheld GPS used to measure water depth and coordinate position (GCP) in the field related to ground check results of analysis of Landsat satellite imagery (Uysal et al., 2015). Tide measurements were used on a scale board with 24-hour observations. They were used to determine the risk caused by sea level rise, where the area tide decline was closely related to the sea level variations and had the potential to amplify or reduce the risk of flooding caused by the sea level rise (Devlin & Adam, 2017). Secchi disk was used to measure brightness to determine the concentration of sediment floating on the sea surface (Azpiroz & Maria, 2017). Sedimen trapp was a tool made from PVC pipes used to trap sediment in order to predict the rate of sedimentation that occurs (Boxhammer et al., 2016). Sediment traps were used to measure the rate of sediment accumulation that had accumulated in the trapp. The measurements could be placed at the desired depth provided that the trapp was still submerged at the lowest tide (Szymkiewicz et al., 2014).

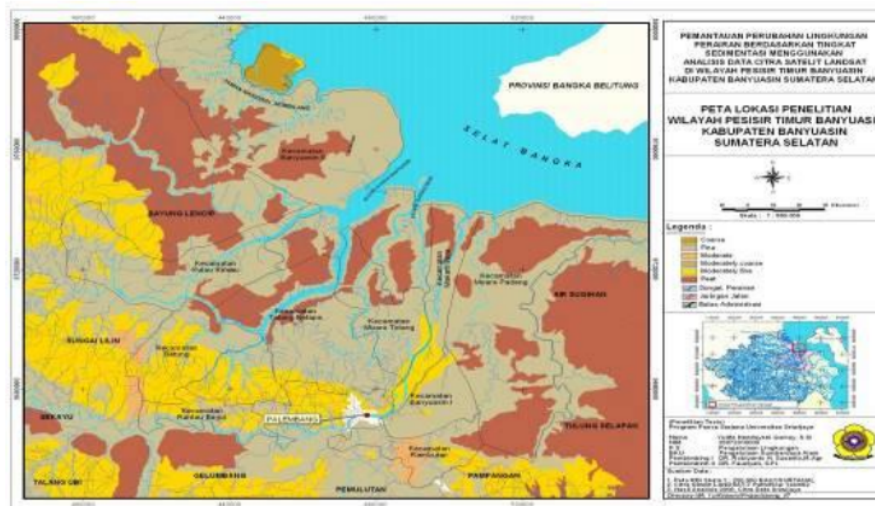


Figure 1. Locations for measurement and sampling





Figure 2. Modified sediment trap design (Windusari et al., 2015)

### Work Procedure

This study used the imagery interpretation method. The sediment data were collected using a Sediment trap equipment to determine the occurrence of accretion and abrasion which were then used to identify the deposition location based on the grain size of the sediment (Shim et al., 2020). The sediment traps were used to obtain sedimentation rates and sediment characteristics (Sihotang & Daniel, 2020).

### Data Analysis

The data analysis in this study used ArcGIS 10.8 software to process the imagery data to obtain the extent of sedimentation and erosion areas. According to (Tiwari et al., 2016), analysis of Landsat imagery could be used to analyze land changes. The Landsat imagery data analysis has been carried out for 29 years, where each image has a supervised classification using the Arcmap software licensed to 10.8 (Sahana et al., 2019), then an overlay was carried out every year for the classified imagery to obtain imagery of land changes occurring during 25 years (1978-2007). The overlay results were then analyzed using the

Intersect feature using the ArcMap and generated new data in the form of a shapefile of the differences in digitization of the shoreline (Finkl et al., 2020). The splits of data were then categorized as abrasion or sedimentation and their areas were calculated, by using the remote sensory technology made it easier to perform analysis to be practical and efficient in time (Foteh & Rahimov, 2018) (Duy & Dinh, 2018) (Chien & Tung 2018). The use of the canal before conducting the analysis also affected the classification results, according to (Windusari et al., 2015), the use of the 243 RGB (1978) and 654 RGB (1992- 2007) canal by using a supervised classification system was considered effective in the classifier according to the original sights in the environment. Then from the results of the classification, the unsupervised classification carried out which was different from the supervised one. This classification used the algorithm as a formulation in determining the number and area of classes resulting from the classification (Sihotang & Daniel, 2020).

## RESULTS AND DISCUSSION

### Landsat Imagery Analysis

The results of data analysis using temporal Landsat imagery (Figure 3) showed that there were fluvial and marine processes that formed the depositional site. This process could be seen in the formation of land forms at several locations in the CAB. Analysis of land formation as a feature of deposition could be grouped based on the results of observations of interpretation of Landsat satellite imagery and groundchecks to determine the geomorphological process. Land formation as a process of activities for rivers that empties into the CAB was identified as an alluvial plain and floodplains that could not be separated due to a large supply of sediment transport. This sediment supply was carried by tidal currents to the CAB and deposited in several locations, namely at the estuary of SL and SB which formed sediment and eventually MTI was formed. For the locations along the TS and TAA, there was an increase in area or a change in the coastline towards the waters that formed the land.

The dominant sedimentation occurred in 1992 amounting to 2.19% of the total classification area (supervised) (Table 1). This was identified because in this year there was an increase in the area of agriculture and plantations so that the existing sediment particles flowed downstream. The sediment deposited in the CAB formed the shoal. It was different in 2007, the area of sedimentation decreased

in size but the agricultural and plantation areas increased. This was because in that year the formed area of sedimentation changed its function to shoals and islands forming new mangrove ecosystem clusters (Zhu et al., 2016) (Chen et al., 2019).

### Land Change

One of the changes in the aquatic environment occurred in the CAB, one of which was caused by the high concentration of suspended sediments of 0.517-1.138 g/L resulting from the large number of sediment particles carried from the upstream to the coastal area, where the average sedimentation rate that occurred in the CAB was 1.81 kg/m<sup>2</sup>/day. The high rate of sedimentation was due to the increased land conversion. The changes occurring in the CAB were in the areas of MTI, Tg Sere, TAA, SB and PP. Taking these five observation locations was conducted in terms of the results of time series analysis of satellite imagery (Table 2) (Figure 4). This was supported by (Finkl et al., 2020) that the use of satellite imagery using satellite sensors was an effective way to collect global data on a regular basis and was able to provide information to monitor ocean dynamics.

Environmental changes occurring in MTI formed islands and shoals. This change was due to the high sediment content which then underwent deposition. The year of 1978 was waters and if the waters condition receded around this location, it formed like accretion (Wang & Jun, 2018).

Table 1. Comparison of the area of environmental changes occurring based on the results of satellite imagery analysis

Class	Area							
	1978		1986		1992		2007	
	km <sup>2</sup>	%	km <sup>2</sup>	%	km <sup>2</sup>	%	km <sup>2</sup>	%
Mangrove	838.21	46.42	815.26	45.15	878.59	48.65	749.95	41.53
Sea Water 1	245.00	13.57	71.82	3.98	183.26	10.15	210.95	11.68
Sea Water 2	253.80	14.05	524.92	29.07	388.89	21.54	320.64	17.76
Sedimentation	32.54	1.80	22.95	1.27	39.49	2.19	30.75	1.70
Shrubs	73.79	4.09	122.95	6.81	78.19	4.33	148.37	8.22
Agriculture and Farm	198.06	10.97	193.87	10.74	226.43	12.54	189.72	10.51

The area of land beginning to form was 362.77 ha (Table 2) in the form of sedimentation. In 1986, MTI was formed of 14.64 ha with an area of 356.42 ha

sedimentation. This could be seen from the increasing area of mangrove forests in the CAB to 815.26 km<sup>2</sup>, which was originally 838.21 km<sup>2</sup> (Table 2).

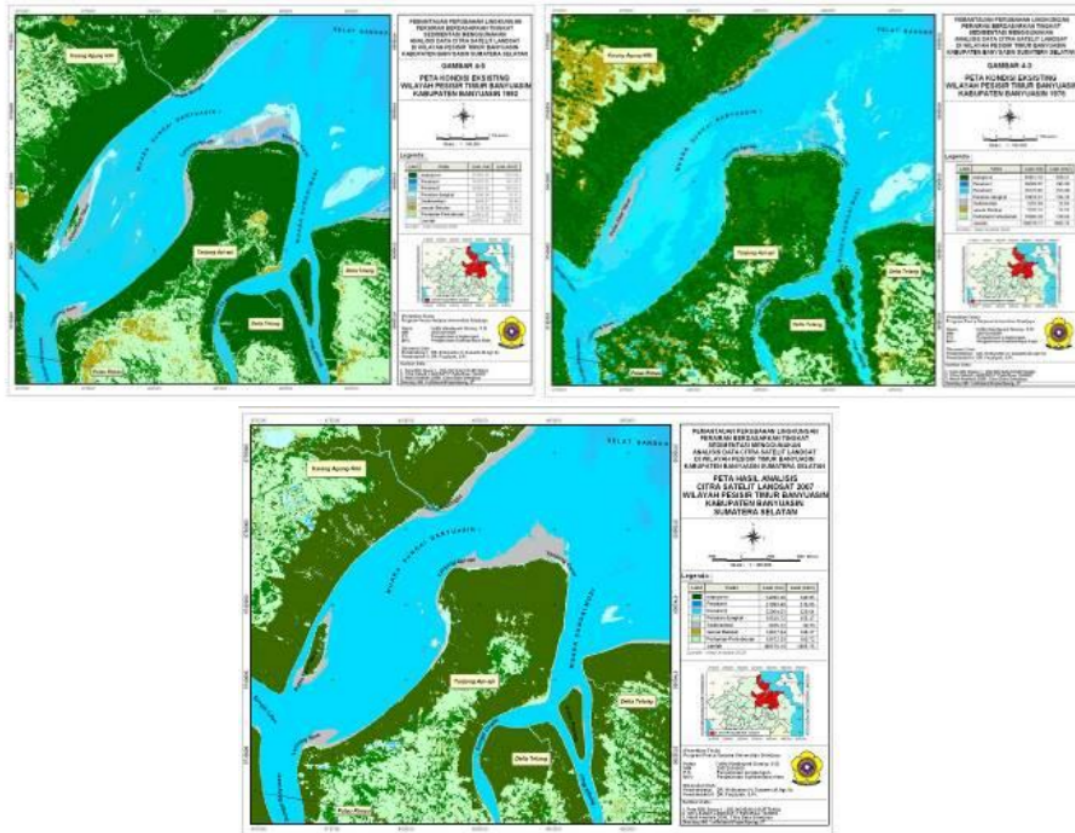


Figure 3. The result of the landsat satellite imagery classified

Table 2. Comparison of island area and sedimentation in several observation locations based on the analysis of Landsat satellite imagery by time series

Location	Area (Hectare)			
	1978	1986	1992	2007
Ekor Tikus Island	0.00	14.64	103.37	206.54
Payung Island	465.49	468.02	521.80	536.79
Sedimentasi PET	362.77	14.64	103.37	258.14
Jumlah	828.26	839.13	912.78	1001.47

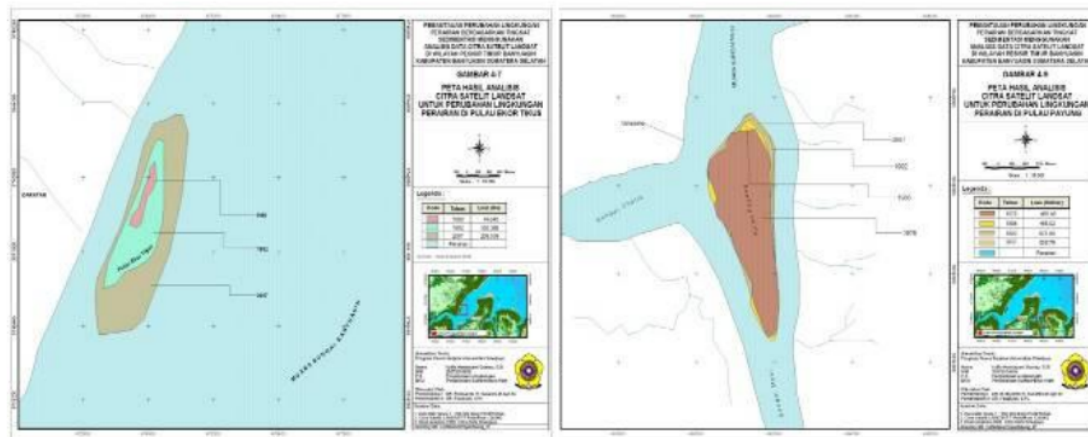


Figure 4. Changes in the area of islands and coastlines in the CAB

### Sedimentation Rate

The CAB was influenced by the Banyuasin River (BR) and the Musi River (MS). These two river estuaries were strongly influenced by the presence of small rivers that flowed and emptied into both of them, the rivers carried sediment particles from upstream to downstream and underwent deposition in this location. The sedimentation occurring in the CAB caused environmental changes, both those that had positive impacts such as increasing land area and those that had negative impacts such as disruption of navigation. The environmental changes occurred in the CAB (Figure 5).

The sedimentation rate that occurred in the CAB ranged from  $0.147 \text{ kg/m}^2/\text{day}$  to  $5.298 \text{ kg/m}^2/\text{day}$ , resulting in a smaller area of water and disruption of ship traffic. Figure 5 shows that the relatively high sedimentation rate was on MTI (st-1), namely  $5.298 \text{ kg/m}^2/\text{day}$ , and the lowest TS (st-5) was  $0.147 \text{ kg/m}^2/\text{day}$ . The high sedimentation rate (SR) at station 1 was thought to have occurred where the two different water masses, SB and SL which carried sediment particles. The confluence of the two water masses gave rise to the energy to be formed to be smaller so that the larger sediments got deposited. This can be seen from the small current speed that occurred compared to other stations, which

was  $0.06 \text{ m/s}$ , the large sediment particles were deposited which then affected the depth value of  $1.09 \text{ m}$ . The low value of the sedimentation rate that occurred at TS (st-5) was because this location had a fairly high current velocity value of  $0.17 \text{ m/s}$  (Table 3) compared to the other stations. As a result, some parts of the sediment in this river flow were carried away to the estuary area. This was in accordance with the opinion of (Sutherland, et al., 2015) that the greater the current velocity in waters, the slower the sedimentation rate will be and conversely the lower the current velocity, the sedimentation rate will increase, which in turn will result in the formation of deltas or new land.

### Oceanographic Parameters of Waters at the Observation Sites

The measured oceanographic parameters of waters included brightness, temperature, depth velocity and direction of currents and salinity. Table 3 CAB Oceanographic Parameters The high percentage of brightness values occurring at the TAA location (st-3) was because at this point it had a relatively large current speed compared to several other locations. The sediment large particles around the location were partly deposited, and the fine or small sediment particles were carried away to the downstream area or the ocean.



The high brightness value occurring at the TAA location can be seen based on the results of the analysis of Landsat satellite imagery, where at this location the changes that occurred were quite significant. The average change of the aquatic environment into a new land at this location was 821.21ha/15 years (1992-2007) or 54.75ha/year (Table 3), having the sedimentation rate occurring at this location to be quite high at 1.340 kg/m<sup>2</sup>/day. This was very likely to happen because the large sediments got quickly deposited and trapped by the mangrove roots to make the sediment concentration decrease. This was supported by Baker (1980); (Tanaka & Kazuya, 2015), that the distribution and size of the sedimented particles depend on the strength of the water current in moving and distributing the suspended solid. The river current velocity also affects the amount of sedimentation rate at the river mouth.

The maximum depth values ranged from 0.23 to 1.09 m at the MTI location while the lowest depth was PP. The locations of PP (st-7), MTI (st-2) and the TAA area (st-

3 and 6) had shallow water depth values. Because the sedimentation rate was quite large compared to the others except for MTI (st-1), so the silting that occurred was quite large at this location. This was supported by (Attal, 2015) (Duy & Dinh, 2018) stating that one of the hydrological processes that causes silting of waters was erosion and sedimentation. The higher the level of sedimentation occurring in waters, the lower the depth value formed in the waters, which will then trigger the accretion or the rise of the bottom of the water to the surface as was the case with PP and MTI which were formed from the uplift of the bottom waters due to high sedimentation process (Figure 7 Depth Distribution Map of Waters in CAB).

The particles that did not settle were carried away downstream. This can be seen from the high brightness of 52.77% compared to those of the other locations and caused the heat energy entering the waters to be absorbed more than it was reflected back so that the temperature that occurred was greater in the waters, that was 31.70 °C.

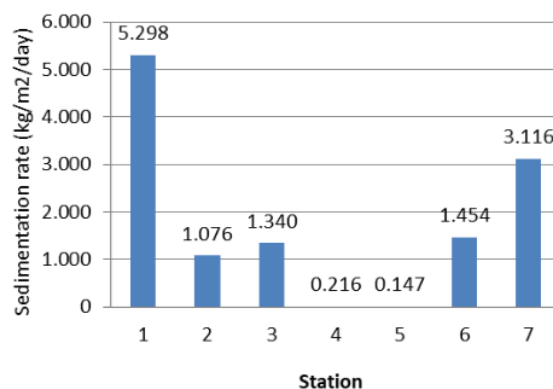


Figure 5. Histogram of average sedimentation rate at the study site

Table 3. CAB oceanographic parameters

Location	Temperature (°C)	Brightness (%)	Depth (m)	Velocity (m/s)	Flow Direction (deg)
Ekor Tikus	30.58	34.75	1.09	0.06	202.0
Band	31.80	7.54	0.27	0.09	230.0
Tg Api-Api	30.72	52.77	0.39	0.33	87.0
Angin River	29.70	30.52	0.81	0.14	221.0
Tg Sere	30.60	44.67	0.72	0.17	116.0
Tg Api-Api	30.72	45.52	0.38	0.24	187.0
Payung Island	31.00	7.23	0.23	0.05	65.0
Total	215.12	223	3.89	1.07	1108.0
Rate	30.73	31.86	0.56	0.15	158.29

## CONCLUSION

In conclusion, there has been a change in land with a decrease in the area of mangroves by 4.89% and an increase in the area of shrubs. Land change resulting from the sedimentation is the formation of PET. With the dominant factor that influences it, that is the occurrence of land conversion from mangrove forests to agricultural, plantation and shrubland areas.

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