SOME PRELIMINARY RESULTS ON STUDYING THE SHORELINE EVOLUTION OF NHA TRANG BAY USING VIDEO-CAMERA TECHNIQUE

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Abstract: *Recently, beside traditional methods which measure basic data of hydrodynamics and sediment characteristic, for investigate shoreline evolution, video camera-based remote sensing is particularly well suited to monitoring shoreline evolution as a new method for observation and monitoring shoreline. It covers timescales from seconds to years and spatial scales from meters to kilometers and possible for monitoring beach morphology as well as dominant factors governing evolution in the nearshore area. The paper presents preliminary results on studying shoreline evolution of Nha Trang bay, Khanh Hoa province using video camera technique, within framework of protocol research project with France "Study on hydrodymic regime and sediment transport in estuarine and coastal zones of Nha Trang bay, Khanh Hoa province".*

1. INTRODUCTION OF VIDEO-CAMERA TECHNIQUE

Hydrodynamic study in the nearshore requires field measurement and observation data. Obtaining detailed measurements of waves, currents and and morphology in the field, especially on a large area is very difficult to implement because of limited funding, instrumentation and human resources. Traditional methods only provide punctual information, limited in time (field experiment duration) and in space (at the locations of the sensors).

Recently, beside traditional methods which measure basic data of hydrodynamics and sediment characteristic, for investigate shoreline evolution, video camera-based remote sensing is particularly well suited to monitoring shoreline evolution as a new method for observation and monitoring shoreline. It covers timescales from seconds to years and spatial scales from meters to kilometers and possible for monitoring beach morphology as well as dominant factors governing evolution in the nearshore area. Numerous studies which used video camera have gone into estimating shoreline position. The main applications are in a) assessing natural beach behaviour [4, 11], b) artificial nourishment efficiency [9], c) and beaches dedicated to recreational use and safety [8].

Monitoring technique, which observed shoreline, wave and currents characteristic using images starts from the 1930s, when the first study of coastal evolution using air-photo has been carried out. However it's not possible to capture shoreline picture continuously using air-photo technique, the cost quite expensive, and limited in poor weather conditions. In 1980, the Coastal Imaging Lab (CIL) of the Oregon University has conducted research and applied successfully video-camera images in measurement wave run [5, 7].

While the traditional methods of field measurements is limited largely by the mobilization of instrumentation, the preparation, logistics and costs, the new method proved advantageous when measuring nearshore hydrodynamics parameters. This advantage is enhanced further when the initial study discovered that the average of images taken within ten minutes (timex) can be used effectively to locate the position of submerged sand bars and channels as well as undertow currents. This approach has simplified significantly compared to the traditional approach [10]. The advantage of the Timex method has led to development of number of automatically coastal monitoring stations at the beach called Argus, in 1992. The system is programmed to collect images of the beach at any time (daytime) and at the positions where are research interested. Until now, such automated monitoring beaches system have been built in more than 30 beaches around the world in countries such as the advanced technology in coastal engineering such as America, France, Netherlands, Australia, New Zealand, Japan and Taiwan.

The camera system which is used for monitoring and describing shoreline position plays an important role in supporting managers and engineers in assessment, analysis beach and shoreline conditions and help to provide appropriate solutions for coastal protection. The main applications of this system including:

- Analysis changing of beach and shoreline, identify the erosion risk or the impact of storm surges on beaches.
- Determine the volume of sediment deposition, surface erosion on the beach. Help assess the impact of coastal protection works to the neighborhood beach and fluctuation of the beach by season. Support in investigate the evolution of artificial beach or studying the nearshore morphological characteristics such as submerged bars, tidal flats at tidal inlet, river mouth and harbor entrance.
- Research the beach terrain in the area of tidal fluctuations.
- Study the flow in coastal areas to assess the safety of the beach and nearshore region.
- Identify the characteristics of nearshore waves characteristic such as wave run-up and wave impacts to the beach and coastal structures.

In Japan, the monitoring system using such type camera is applied on most of the major coastal estuaries and river systems such as the Kitakami, Naruse, Natori, Mabuchi, Yoneshiro and Nanakita in Miyagi Prefecture; the river systems in the region of Tokyo, Osaka and Kobe also installed camera system for monitoring and providing early flood warning (references ?). The camera can be set up in advanced to capture pictures at designed time. In normal conditions, it is setup to take picture every hour, in extreme weather conditions such as storms or floods, the frequency for taking picture can be shorter. When a sequence of images has been captured, the morphological factors such as the width of the river mouth, the length of the sand, erosion levels and so on will be determined based on the fixed position in the image or simply compare the marginal distance as shown in Fig. 1. In order to calibrate the system, we have to set control points with known coordinates both on the image, in pixels, and in the in the field (in real world coordinates)..

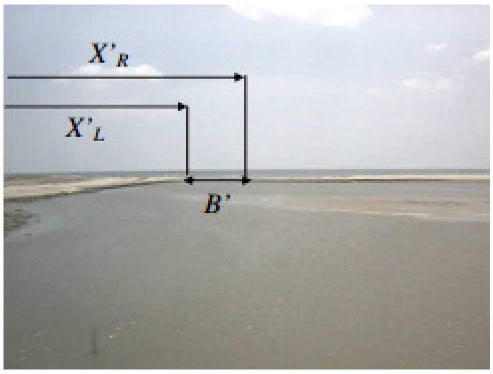


Fig. 1. Installation of the camera and determination of river mouth width $B' = X'_R - X'_L$
(Image from the camera system at Nanakita River, Miyagi Prefecture, Japan)[12]

For areas which under tidal influence, one must adjust the parameters measured by the amplitude of the tides at the time of observation. For example, the river mouth width was originally identified by mark "0" on nautical chart, then based on topographical map the slope of tidal flat during low tides and high tide can be determined. The formula for adjusted the distortion will be $\Delta X = -\Delta H / I$. In which, ΔH is water level difference compared to mark "0" on nautical chart at capture time and I is beach slope.

In the study of Tanaka and Nguyen (2007), camera technique can also be used for monitoring changes in the river mouth width and the continuous development of the sand bars at the estuary over time [12]. Measurement technology with stereoscopic camera images are used in laboratories to measure the flow velocity surface technology called PIV (Particle Image Velocimetry - Measuring velocity by particle motion picture).

Recently, in Vietnam, a new research on shoreline change detection and estuarine monitoring technique has been carried out in the National Scientific and Research Program named "Research to proposed seasonal monitoring, measuring system for estuarine area along the Central Vietnam, by Dr. Nghiem Tien Lam, 2012. The research has implemented a piloted monitoring system at the Canh Duong beach of the Thua Thien Hue province. The research has indicated that video-camera technical can open up to a new direction for monitoring and supervising the evolution of estuary and beach on a regular basis at low cost, to provide information and data for research, planning and management of coastal and river areas in Vietnam.

2. METHODOLOGY OF VIDEO-CAMERA TECHNIQUE

The data analysis and processing from camera are online transmitted based on the principle of topography. There is a convention coordinate as: x axis perpencular with the coastalline, positive direction to the offshore, y axis perpencular with x axis, z axis oriented upward with the datum z=0 as seen in Fig. 2 [6].

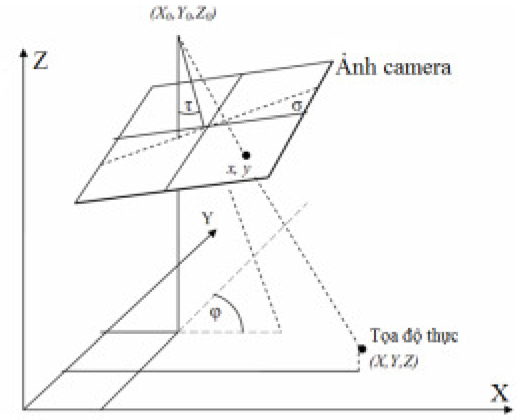


Fig. 2. Relationship between camera coordinate (X_0, Y_0, Z_0), image coordinate (x, y) and real coordiate (X, Y, Z)[6]

From relationship between image coordinate (X_0, Y_0, Z_0) and one real point with (X, Y, Z) coordinate and image (x, y) corresponding to the position of image point, a formula to convert real and image coordinate as follow:

$$X = (Z - Z_0).Q + X_0 \qquad (1)$$

$$Y = (Z - Z_0).P + Y_0 \qquad (2)$$

In which:

$$Q = \frac{(m_{11}x + m_{21}y - m_{31}f)}{(m_{13}x + m_{23}y - m_{33}f)} \qquad (3)$$

$$P = \frac{(m_{12}x + m_{22}y - m_{32}f)}{(m_{13}x + m_{23} - m_{33}f)} \qquad (4)$$

With m_{ij} is a element of M(3x3) matrix:

$$M = \begin{pmatrix} \cos(\alpha) & \sin(\alpha) & 0 \\ \sin(\alpha) & \cos(\alpha) & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\tau) & -\sin(\tau) \\ 0 & \sin(\tau) & \cos(\tau) \end{pmatrix} \begin{pmatrix} -\cos(s) & -\sin(s) & 0 \\ -\sin(s) & \cos(s) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

In this study, authors have developped a program in MATLAB language to analysis and interpret shoreline evolution in Nha Trang bay. The following steps illustrate detailed image processing by using video camera technique on shoreline changes in Nha Trang bay [1, 2, 3, 12].

Step 1: calibration of camera image

It is necessary to know at least 6 controlled points in UTM system from GPS devices to calculate parameters for image analysis. In reality, determination of above mentioned parameters are very difficult, therefore, in this specific research a technique to determine minimum error corresponding to camera focal length is used as seen Fig. 3.

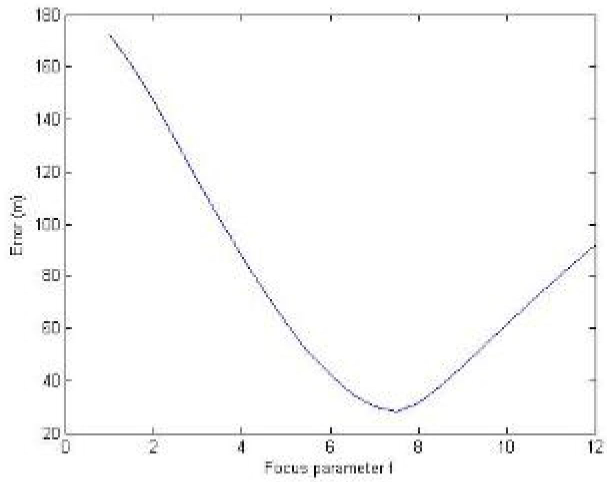


Fig.3. Relationship between error and camera focal length

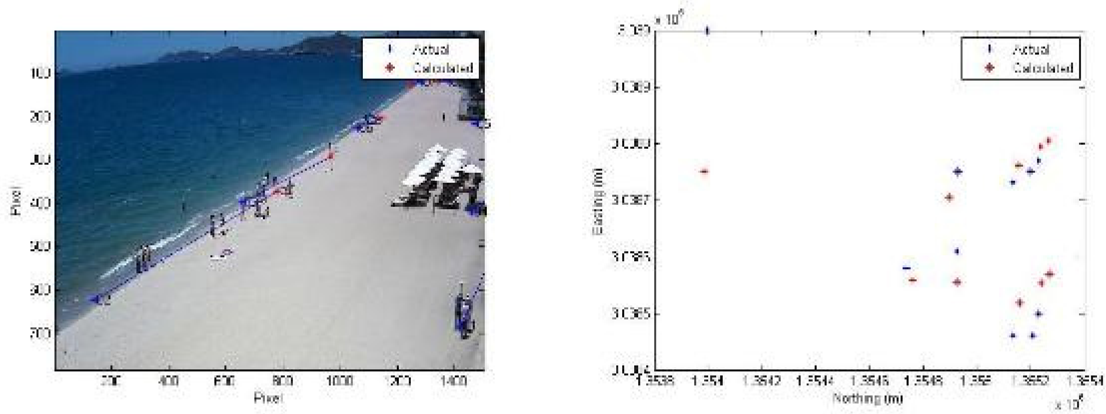


Fig. 4. Relationship between calculated coordinate from camera and real coordinate

Step 2: creation of averaged images and stack image

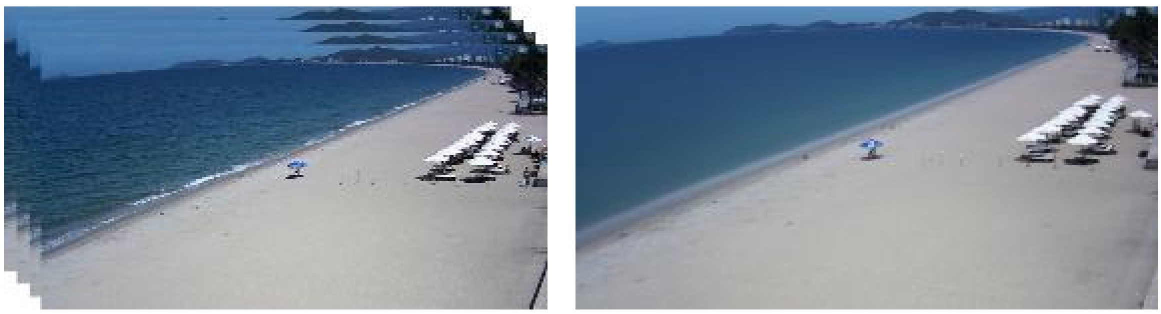


Fig. 5. Creation of averaged images and image after processing from South camera at 12:00 on 1st July 2013

After getting the correlation between calculated image and real coordinate (see Fig. 4), a creation of averaged images from video file can be obtained as seen in Fig. 5; and stack image as seen in Fig. 6 with the purpose to detect the shoreline.

Fig. 6. Stack image after processing

Step 3: Shoreline detection

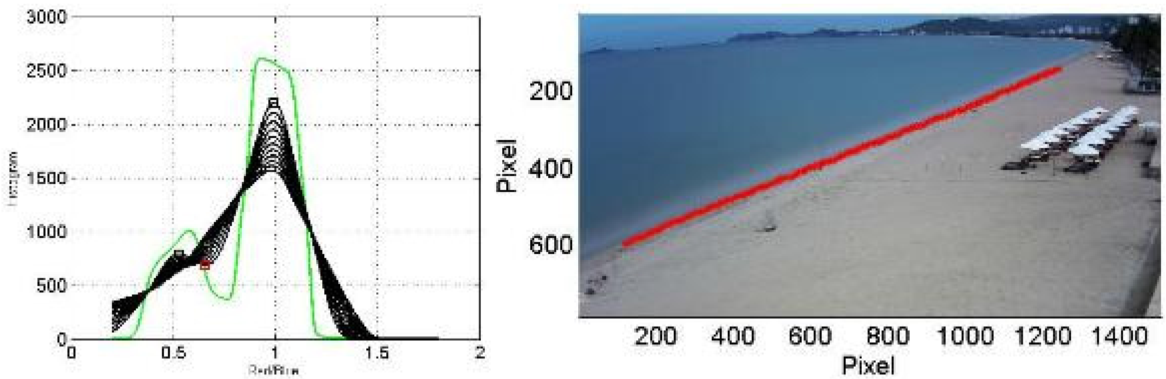


Fig. 7. Description of shoreline detection and interpretation result based on camera images (with x, y are pixel units)

Fig. 7 shows detection process via colour band difference: sea colour (dominant Blue) and beach (dominant Red). The position of shoreline can be determined by ratio between red and blue.

Step 4: Calculation of wave parameters

After automatic detection the coastal line via the color spectrum, wave dynamics parameters are also determined as seen in Fig. 8.

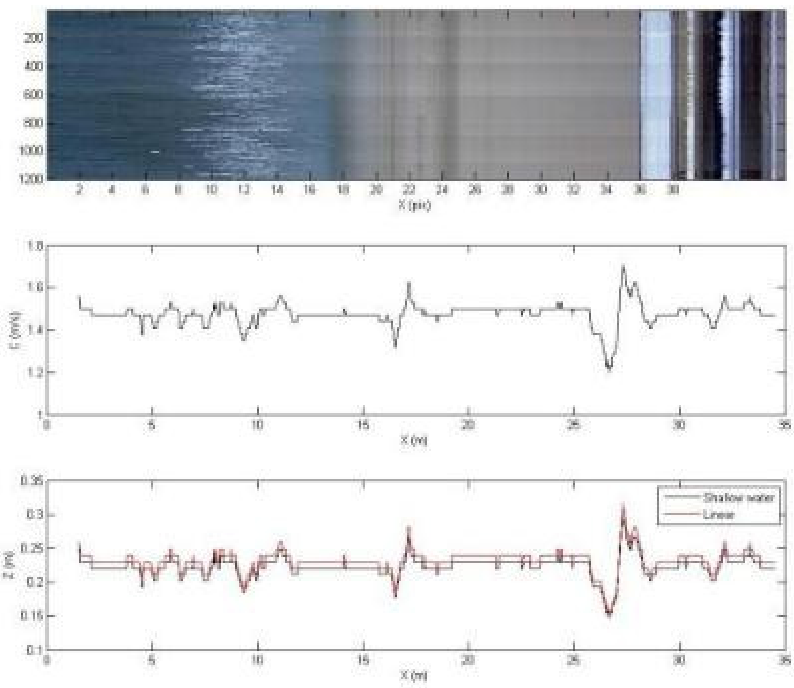


Fig. 8. Calculated results of wave dynamics parameters

3. SOME PRELIMINARY RESULTS ON SHORELINE CHANGES IN NHA TRANG BAY

Nha Trang bay located in Eastern direction of Nha Trang city, belonging to Khanh Hoa province, bounded by the North-Ke Ga edge, the South-Dong Ba edge. Its area about 500 km^2, Nha Trang bay is covered by 19 small and medium islands. The study area in Nha Trang bay is shown in Fig. 9.

Fig. 9. Study area of Nha Trang bay, Khanh Hoa province

Under framework of the protocol research project in collaboration with Institute for Research and Development (IRD), France entitle "Study on hydrodynamic regime and sediment transport in estuarine and coastal zones of Nha Trang bay, Khanh Hoa province", shoreline monitoring system in Nha Trang bay was conducted by video-camerea monitoring technology. Two cameras (01 camera toward the North, namely NNT and 01 camera toward the South, namely SNT) were embedded with electricity pole along the Tran Phu road, just in front of Khanh Hoa post office as seen in Fig. 10. The online transmitting line with broaden band, connected directly from VNPT Khanh Hoa to the processing center at Water Resources

University. The following web links on NNT and SNT: http://113.252.160.106 and http://113.252.160.107 (corresponding to username and password are viewer) can be easily accessed via internet.

Fig. 10. Location of camera deployment monitoring the shoreline changes in Nha Trang bay (a. Camera toward the North, b. Camera toward the South)

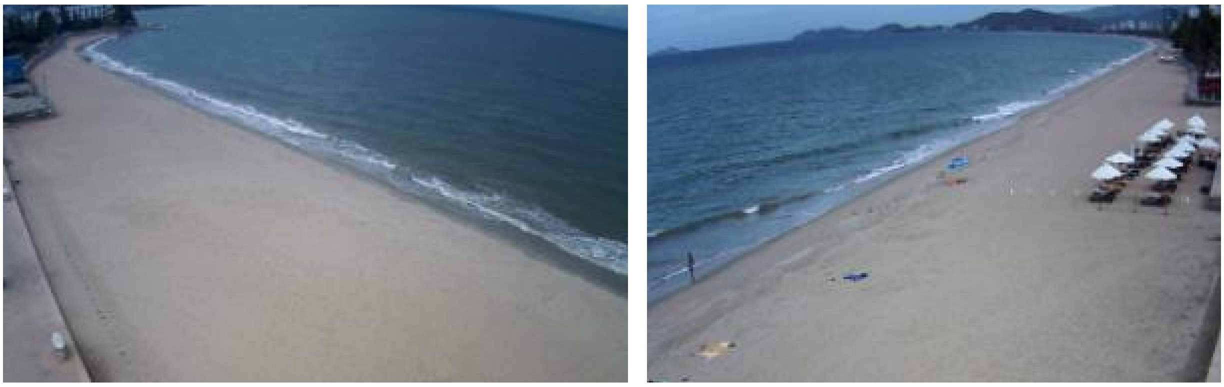


Fig. 11. Photographs showing coastline in Nha Trang bay (a. Photo taken toward the North, b. Photo taken toward the South)

Fig. 11 represents two photographs taken at 13:00 on 31 May 2013 toward the North and the South corresponding to Fig. 15a and Fig. 15b, respectively. Through the detailed analysis of camera image during the period of time 23 to 30 May 2013, the computed shoreline changes fit well to observed data by DGPS as shown in Fig. 12.

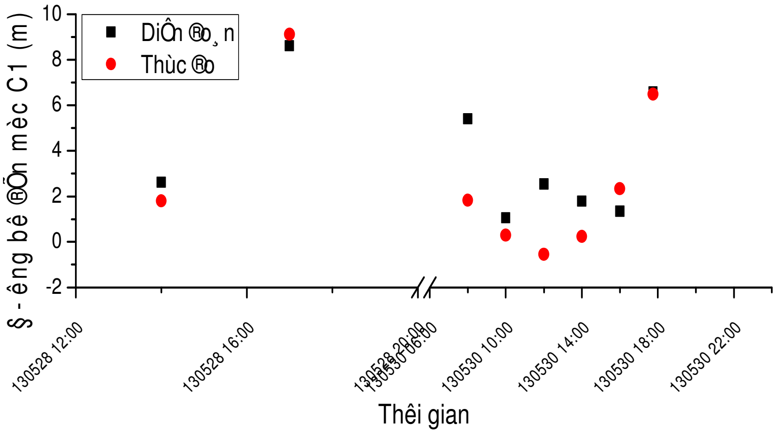


Fig. 12. Comparison of computed shoreline result by camera and measured by DGPS

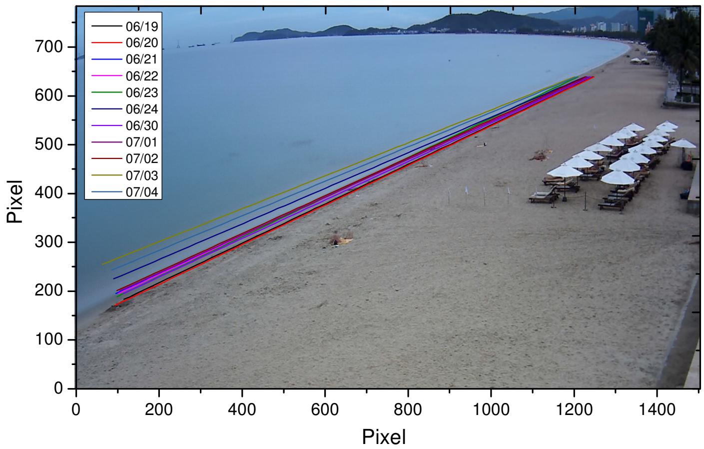


Fig. 13. Simulation results of shoreline changes in Nha Trang beach in pixel unit (from 19 June to 4 to July 2013)

From shoreline evolution as above mentioned, it is easy to determine the daily sand volume changes as shown in Fig. 14. This is an interesting parameter and important for professional manager in decision making of policy planning.

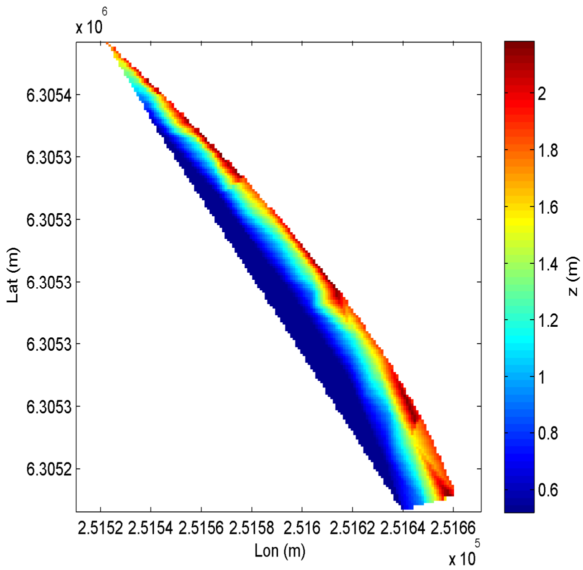
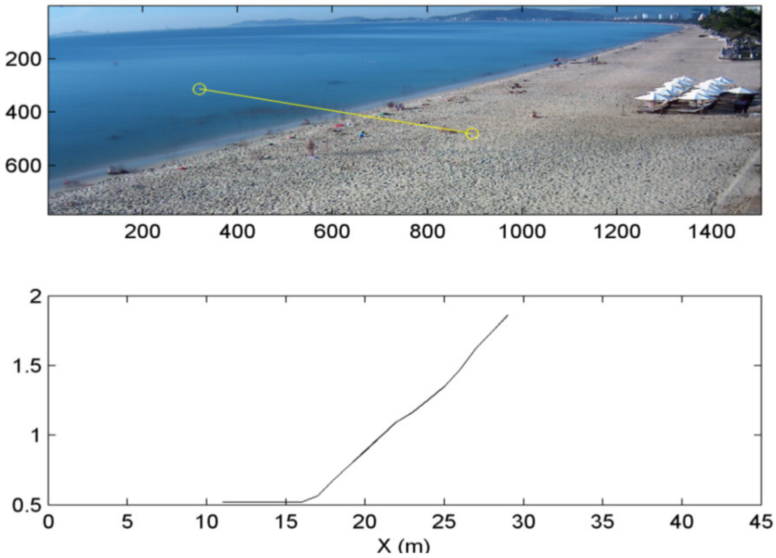


Fig. 14. Changed sandy volume in intertidal zone in 28 May 2013



Hahn 15. Determination of cross profile of Nha Trang beach on 28 May 2013

Fig. 15 shows a simulated cross profile of Nha Trang beach on 28 May 2013. This is an important parameter and plays a significantly role in simulating scenarios to propose good countermeasures to sustainable estuarine and coastal zone.

4. CONCLUSIONS

The monitoring technique on the evolution of estuarine and coastal zone by using video camera has first been conducting in Vietnam. This study presents some preliminary results on shoreline changes in Nha Trang beach under frame work of the protocol project "Study on hydrodynamic regime and sediment transport in estuarine and coastal zones of Nha Trang bay, Khanh Hoa province". The preliminary results indicate that the monitoring technique on shoreline changes in Nha Trang beach is very significant and it obviously illustrates a good and appropriate tendency and general picture on seasonal evolution of shoreline in Nha Trang beach. This detailed study on shoreline evolution will play an important role in calibration and verification for numerical model in order to forecast the long-term evolution of estuarine and coastal changes in Vietnam.

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