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論文名稱: 集水區空間資訊萃取及坡面泥砂產量推估之研究

英文論文名稱: Automated Watershed Delineation for Spatial Information Extraction and Slopeland Yield Evalution

【中文摘要】

水土保持之理論基礎及實務應用多以集水區為評估單元，往昔集水區資訊之萃取主要以人工方式量測，近年來隨電腦科技之進步，數值高程模型資料於集水區自動劃分及水系網萃取的技術已臻成熟，利用電腦量化集水區資訊應用於坡地災害分析為時勢所趨。有鑑於此，本研究以集水區自動劃分理論為主軸，針對窪地出口、流向迴路、集水區門檻值劃分及水系網萃取等項目，提出窪地集水區、動態集水區劃分及多重門檻值水系網萃取等改進方法；以石門、德基及曾文水庫集水區為驗證樣區，自動萃取集水區範圍及水系網分布，結合空間分析以自動萃取集水區之地文與水文資訊。另由集水區自動劃分理論，結合通用土壤流失公式(USLE)及泥砂遞移率(SDR)之計算，撰寫專家系統介面，建立集水區坡面泥砂產量推估模式，由石門、德基、曾文水庫及二仁溪上游集水區為驗證區域，推估集水區土壤沖蝕量及坡面泥砂產量之空間分布，其結果分述如下：

藉由高差法(Jenson and Domingue, 1988)及本研究所推導之斜面法能計算集水區之初始流向，輔以窪地集水區法結合 PROMETHEE 理論計算建立集

水區之無窪地流向。石門、德基及曾文水庫集水區之流向計算，與傳統方法(高程平滑化法、窪地填高法及逐步填高法)比較，以窪地集水區法最為精確。本研究所研發之集水區動態萃取方法，使用者僅需指定出流口，電腦即可自動追跡流經該點之所有排水區位，獲得集水區範圍；以石門、德基及曾文水庫集水區之水庫大壩為出流口，動態萃取之集水區面積為 75634 ha、52367 ha 及 48395 ha。而真實水系網之萃取，由於集水區之地形、地質、土壤及氣候為非均一性，單一門檻值所萃取水系網無法代表真實水系網，本研究以多重門檻值取代傳統單一門檻值，其結果可確實反應水系網分布現況。

集水區坡面泥砂產量之推估結果，石門、德基、曾文水庫及二仁溪上游集水區之年泥砂產量分別為 1928168 tons/yr、1793742 tons/yr、4807205 tons/yr 及 5074396 tons/yr，年平均沖蝕深度分別為 1.82mm、2.45mm、7.10mm 及 25.81mm，以有泥岩分布之曾文水庫及二仁溪上游集水區較為嚴重。集水區坡面泥砂產量推估以 Nash and Sutcliffe (1970)公式所計算之模式效率( )為 81.21%，另由集水區泥砂產量推估值( )與實測值( )相關分析結果，呈顯著正相關， 。由集水區泥砂遞移率特性分析，顯示 之地區屬高遞移率區位，石門、德基及曾文水庫集水區內高遞移率區位之面積雖佔集水區之 10.58%、9.21%及 10.01%，其泥砂產量百分比可高達集水區之 46.99%、49.20%及 46.47%，為集水區泥砂來源之敏感區位。

【英文摘要】

Watershed unit has been regarded as an analyzed object for slopeland disaster assessment. With the fast growing progress of computer technologies, instead of manual operation, there is a trend of applying Digital Elevation Model (DEM) in automated watershed delineating and drainage network design. This study first focused on improving extraction method for automated watershed delineating. The concepts for depression outlets decision, looped drainage direction calculation, reasonable watersheds area delineation, and simulation of realistic drainage networks are all revised to propose a new approach for more reasonable and efficient in watershed delineation. Three major reservoir watersheds (Shihmen, Techi and Tsenwen) were chosen to calculate watershed geomorphologic and hydrologic information for verifying the suitability of proposed approach. An expert system was also developed using the approach included Universal Soil Loss Equation (USLE) and Sediment Delivery Ratio (SDR) to estimate watershed sediment yield. The system shows good performance for Shihmen, Techi, Tsenwen reservoir and Erzen creek watersheds. The results are summarized as follows:

Using DEM to derive drainage directions of a watershed is frequently used in recent study. However, determinations of the optimal outlet and drainage directions for the depressions should be improved for fitting the real field data. This study proposed surface-inclining approach to couple with elevation-differencing approach (Jenson and Domingue, 1988) for determining incipient drainage directions. The calculation of optimal outlet and drainage direction in the depressions can be performed using watershed depression approach with PROMETHEE theory. Compared with elevation-smoothing, depression-filling and repeatedly elevation-incrementing approaches, the drainage directions for Shihmen, Techi and Twensen reservoir watersheds calculated by watershed depression approach show more reasonable and realistic outcomes. A dynamic extraction technique for tracing upstream drainage area based on user-specified outlet is also developed for fast automatically watershed delineating. The watershed area extracted for Shihmen, Techi and Twensen reservoir with the outlet located at the site of dam is 75634 ha, 52367 ha and 48396 ha, respectively. Due to inhomogeneous characteristics of geomorphology, geology, soil and/or climates of a

watershed, the real drainage networks can not be delineated properly using single-threshold approach. Instead, a multiple-threshold approach is developed to cope with the real spatial distribution of streams in a watershed.

Annual watershed sediment yield calculated for Shihmen, Techi, Twensen reservoirs and Erzen creek is 1928168 tons/yr, 1793742 tons/yr, 4807205 tons/yr and 5074396 tons/yr, and the corresponding annual erosion depth is 1.82mm, 2.45mm, 7.10mm and 25.81mm, respectively. Tsenwen reservoir and Erzen creek show higher erosion depth because of moderate mudstone distribution in the watershed. Model efficiency by Nash and Sutcliffe (1970) for sediment yield estimation is 81.21%, the model (,) shows significant correlation between estimated ( ) and measured ( ) data. The sites with can be clustered as higher sediment delivery sites from characteristic curve analysis. Area percentage of higher sediment delivery sites occupied for Shihmen, Techi and Tsenwen reservoir watersheds are only 10.58%, 9.21% and 10.01%. While the sediment yield percentage for the respective watershed can reach to 46.99%, 49.20% and 46.47%. It shows that higher sediment delivery sites are the main source of soil erosion.