GIS-Based Methods for Rural Land Use Analysis Based on Integrated Agricultural Control Systems IACS

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1. Introduction

This paper presents a method for land use system analysis for use in rural areas. The method combines a nation-wide digital field map and a nation-wide agricultural database. The origin of these data is connected the EU statutory instrument 3508/92 regarding the establishment of an Integrated Agricultural Control System (IACS) in all member countries. The paper presents the primary work of an ongoing project that develops methods for up scaling of detailed data derived at micro and mesochore level.

The project is part of a major research programme initiated by four Danish Research Councils in 1995 titled: **Man, Landscape and Biodiversity**. The project named **Boundaries in the landscape** focusses on Physical, Biological and Normative boundaries and farm structures which follow different productive and recreate uses of nature and runs from 1995-1999. The 13 subprojects in the program are characterized by an inter-scientific approach, and uses a comprehensive data set organized in a GIS, 13 scientists at different universities and sectorial institutes participate in the project.

2. Objectives

This part of the project aims at developing methods for land use systems analysis at different levels. The objective is to use the nationwide agricultural IACS databases that are updated yearly, and combine them with different GIS themes. This will create the basis for further development of methods to integrate socioeconomic, nature- and agricultural data in up scaling scenarios.

3. GIS

The development of modern GIS technology gives an opportunity to improve cooperation in interdiciplinary projects. Advanced technology combined with extensive use of databases enables an integrated program and enhances the exchange of information between projects. The new technology used at macrochore level has resulted in an increased appreciation for the importance of processes at microchore level (e.g. Barret 1992). A drawback is that information on detailed levels as micro- and mesochore often results in a considerable

amount of data and therefore methods have to be developed to aggregate this information to macro and megachore levels. Several studies have recognized the need for applying a systems approach when studying the context of the landscape (Duivenbooden 1995, Zonneveld 1995, Liberman & Naveh 1993, Forman & Godron 1986) and agricultural systems. Nevertheless it is only recently that the development in remote sensing and GIS technologies has made it possible to conduct comprehensive analyses at macrochore level.

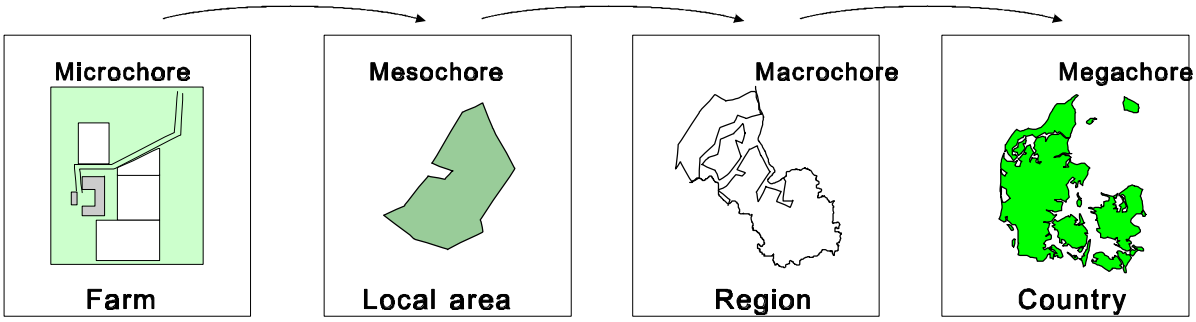

Figure 1. Data on different levels.

This project uses GIS technology to conduct analyses at different chorological levels by using a bottom up approach, a comprehensive nationwide map base containing trans-disciplinary digital maps at scales from 1:10000 to 1:500000, is used in this approach. Topographic and administrative, socioeconomic and landscape data in more than 40 themes are stored in the GIS database. A Desktop GIS (Arcview), established at Research Centre Foulum was made available to project participants.

4. IACS Databases

The IACS databases are a part of an integrated control system designed to administrate and control EU subsidy applications, veterinary events and national environmental regulations. The conceptual framework was established in 1992 by the EU statutory instrument 3508/92 and comprises:

- A database
- A system to identify of fields
- A system to identify and registration of animals
- A subsidy application procedure

At the national level all IACS information can be geo referenced to address coordinates or to a ‘large scale field map’. This field block-map is a nationwide digital vector theme with polygons containing 1-10 fields.

The most important spatial basis is the field block theme that is connected to the address coordinate register. Data from the IACS include information about properties, production units, field size, crop, number and type of animals, farm holdings’ assessment and farmer is age. This information is made available and visualized through the established connection.

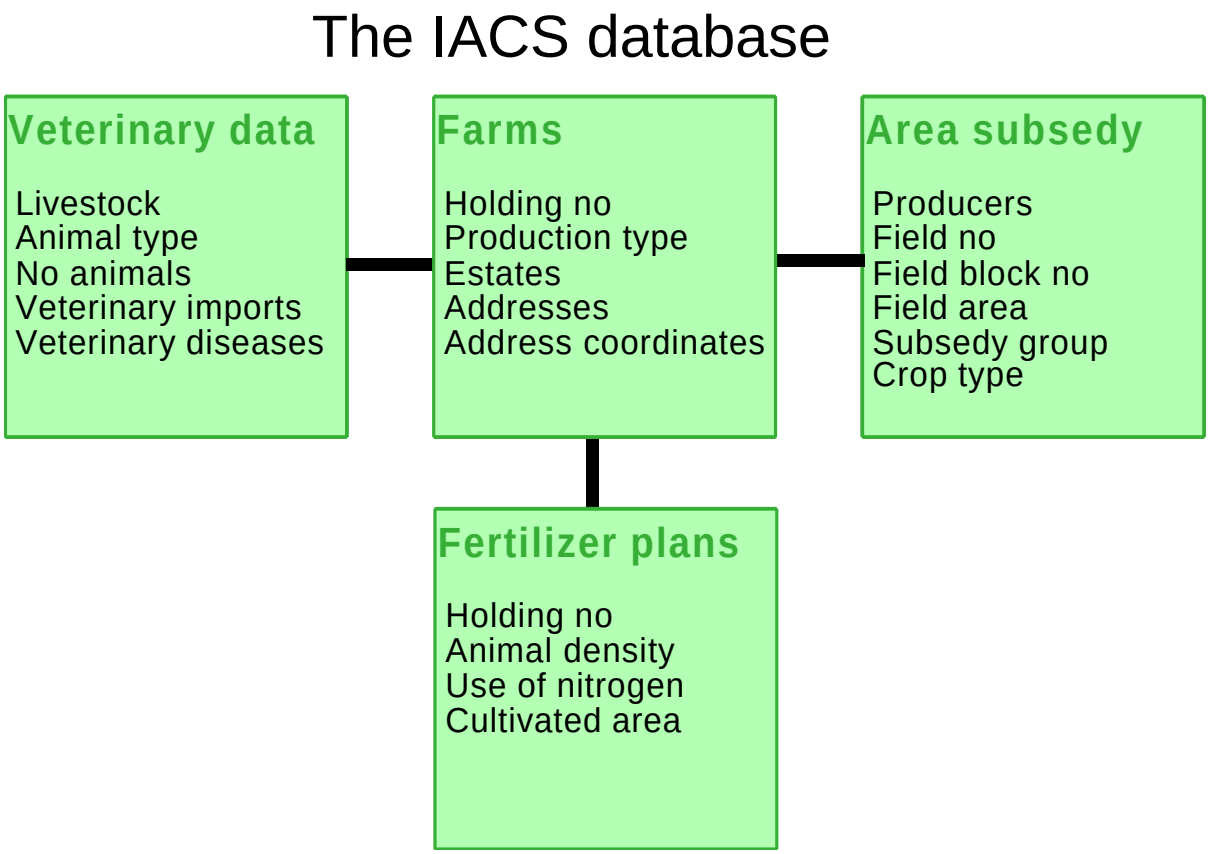

Figure 2. Data in the IACS database

5. Methodology

A GIS database was constructed containing themes of both administrative and topographic origin, including a high resolution elevation model. The digital field map was connected to the IACS agricultural database GLR (General Agricultural Register) enabling data such as cropping, ownership, farm type etc. to be analyzed at the farm level. The method was developed by using farm data at microchore level. The objective was to enable analyses at higher chorological level by aggregating the high resolution data from lower levels.

Questionnaires were filled out of 430 farmers. The interviews are used to check the land use information in the IACS database (Figure 3). Field investigations are conducted to verify the digital maps by use of The Integrated Transect Method (ITM) (Duivenbooden 1995). By use of linear transects of different size and resolution knowledge on errors and generalization level is derived regarding the digital maps. Combined with the use of aerial photos, the method may be used to select the best-suited maps for analysis at specific chorological levels. The selected maps are then used in the process of up scaling as shown in figure no 3. This up scaling is only posible by using of the IACS and GIS databases that were verified by the Integrated transect method at micro- and mesochore level.

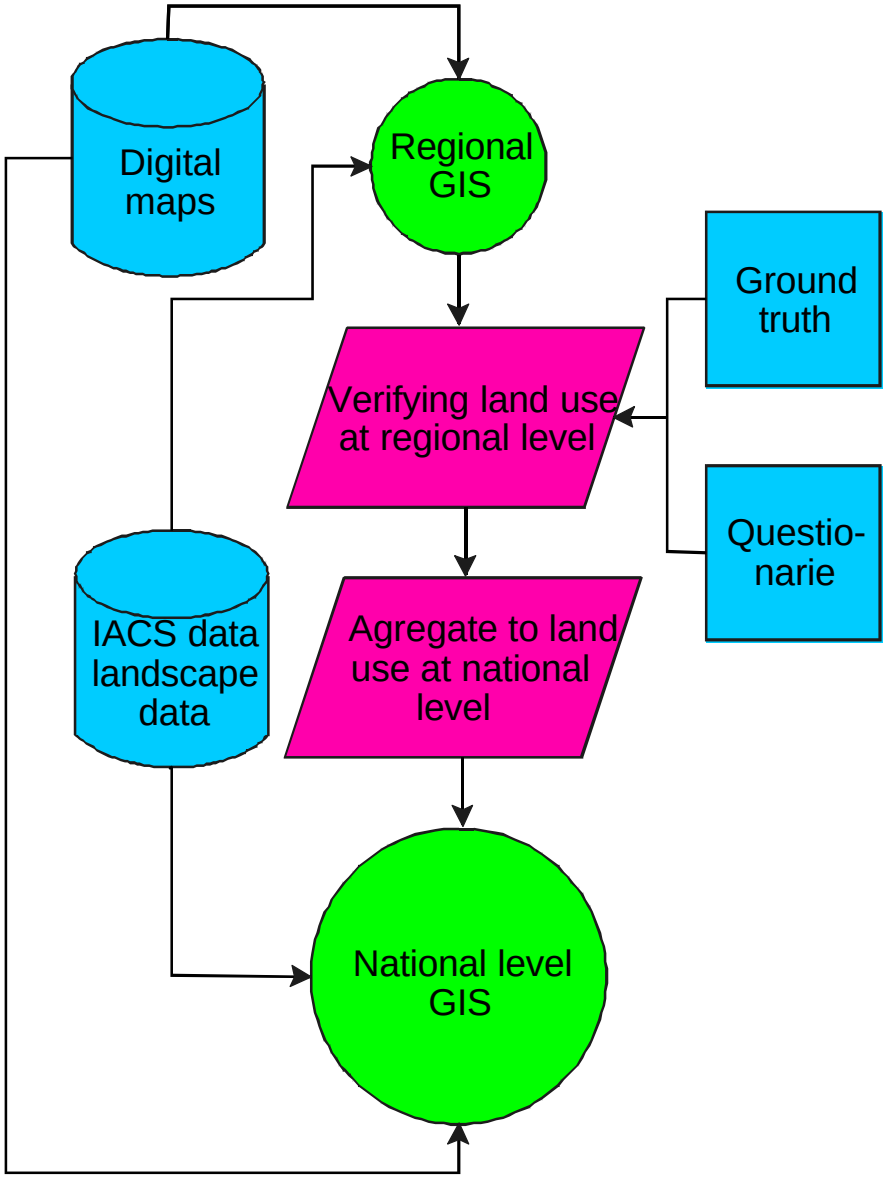

Figure 3. Schematic representation of the IACS database

6. Project Area

The project area chosen is situated in central Jutland, 30 kilometers south west of Randers. The area is 156 km2 and very suitable because it contains rural and urban zones and because it is representative for many nature- and landscape types in Denmark. The soil types vary from fertile loamy soils to fine and coarse sandy soils. A high-resolution field map that comprises more than 2800 fields has been established for the area and connected to

the IACS databases. Here by the content of the IACS database is made available at field level as shown in figure 4. The figure illustrates different land utilization types practiced in a parish in the project area near the village of Vellev.

7. Up scaling Crop Information

Information from field level is used to verify information on higher levels by fieldwork and GIS analyses. On the field block map, a single block contains 1-10 fields and information is stored as ratios inside the block. This simplification enables analyses and queries even at regional and macrochore level as figure 5 illustrates.

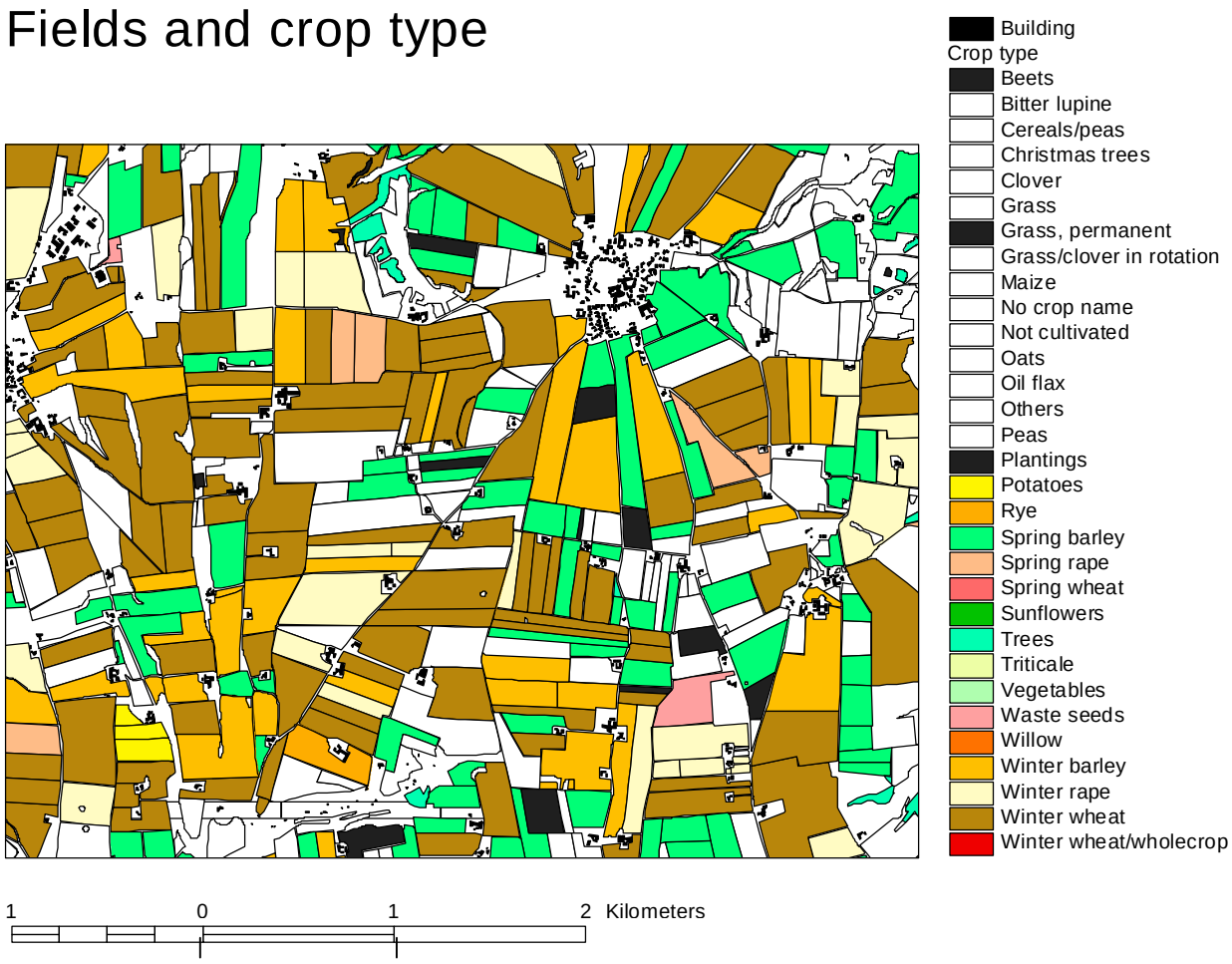

Figure 4. Different land utilization types near the village of Vellev.

The figure shows the distribution of winter wheat. It illustrates how the land use varies in the project area. Every field block contains the ratio of winter wheat inside the block. The map shows that wheat is grown on the higher loamy soils, whereas no wheat occurs on the sandy and organic soils of the river valley. Due to the complexity of the maps only the distribution of winter wheat is shown in figure 5

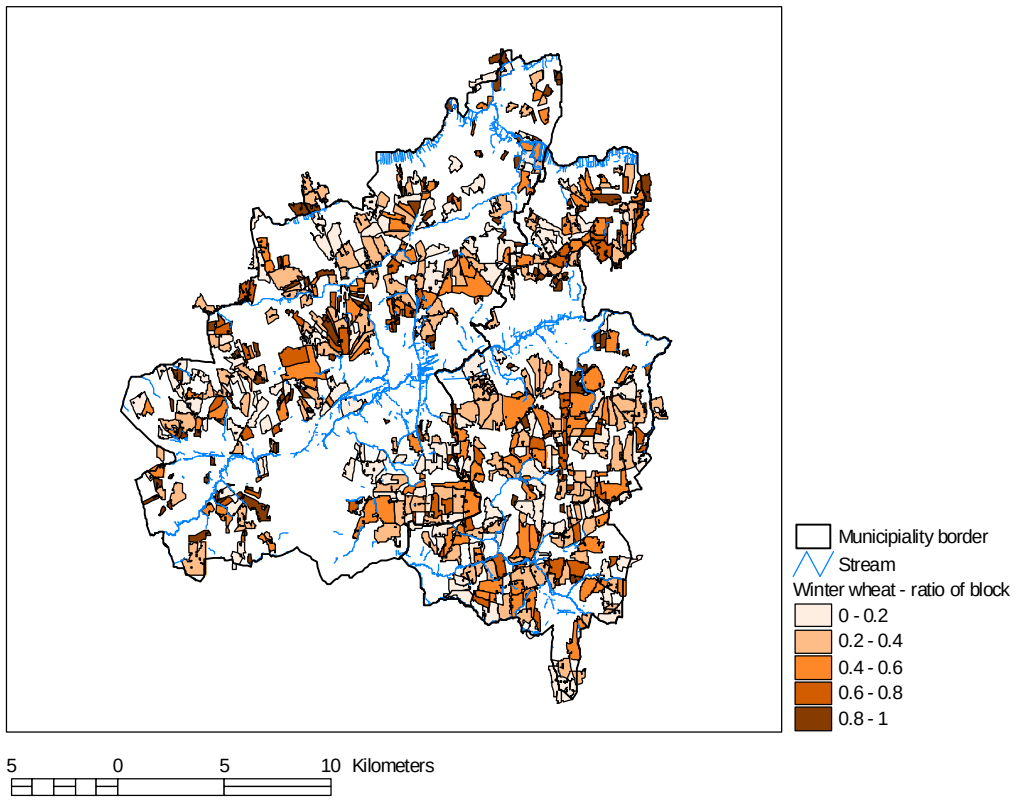

Figure 5. Distribution of winter wheat relative to streams.

8. Environmental Analyses

The developed system is well suited for environmental analyses at county level. A typical example is an analysis of the producers' need for area for manure to spread out and the counties' need for drinking water areas. In several agricultural areas of Denmark the nitrate content of the drinking water is higher than 50 mg/l which makes it unsuitable as drinking water. The problems of getting high quality drinking water will not be solved easily in the coming years, the yearly Danish pig production is 20 mill. pigs a year but is rising fast and is expected to be 23 mill in year 2000. The combination of IACS and GIS can be used for planning at county level, information on extensive and intensive agricultural areas can be obtained through this combination. Combined with environmental information on county level, risk/conflict areas can be pointed out.

Figure 6 shows producers with high (red) and low (green) demand for additional land to deposit their surplus of manure. These ratios have been calculated by use of information on animal units. Environmental protection areas are shown with fine hatching. Drinking water areas are shown with coarse blue hatching.

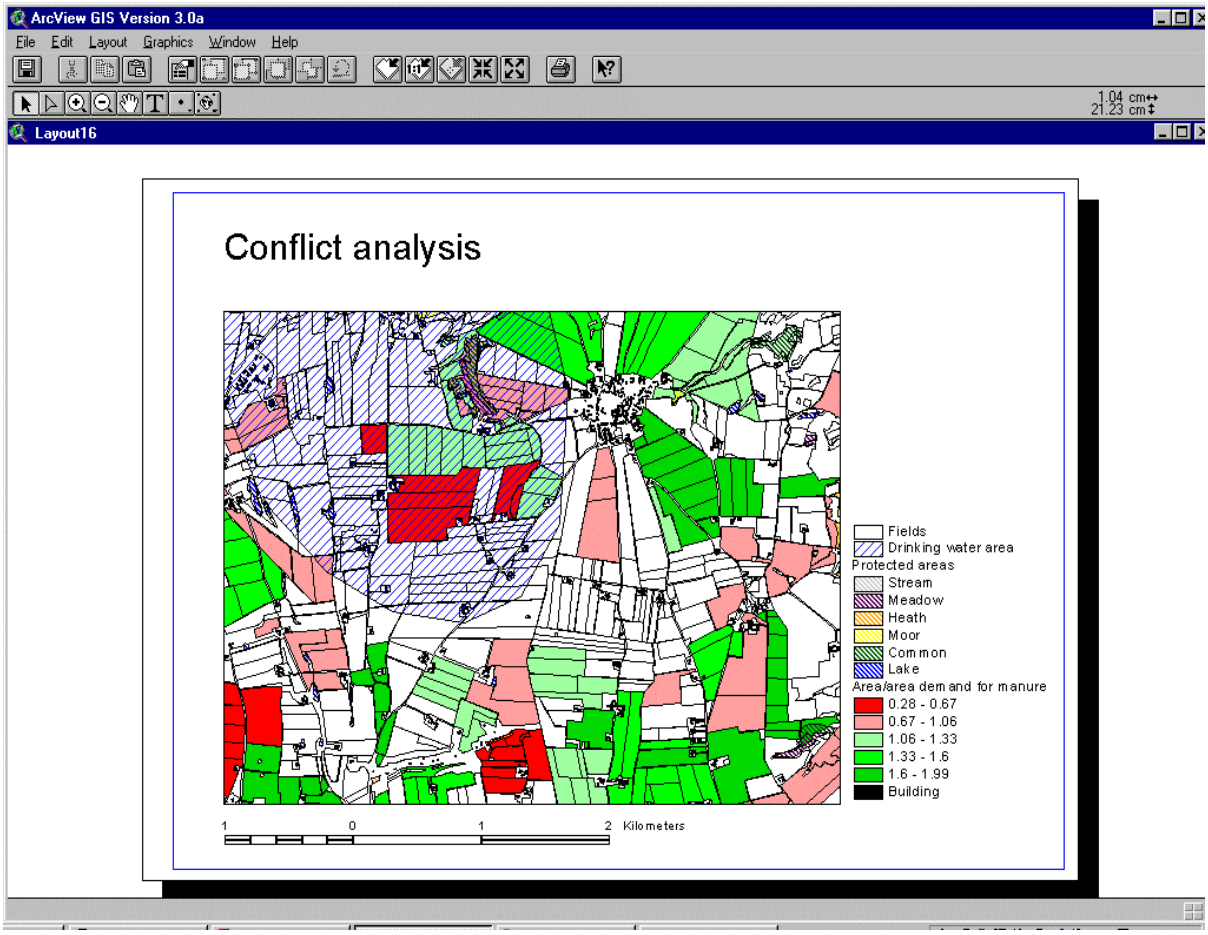

Figure 6. **Producers with high (red) and low (green) demand for additional land to deposit their surplus of manure.**

9. Results

So far, this method has been developed for use at mesochore to macrochore levels. But the project has also demonstrated the prospects of high resolution GIS at the megachore level. The combination of environmental and agricultural data has shown to be useful in planning at macrochore level and benfits from the bottom up approach.

Development of the method will continue during this project. However, it is already clear that combining the annually updated IACS data with different thematic maps has created a new and powerful tool for planning and analysis

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