

**Detection of Quasi Formal Homestead Divisions (QFHDs)
via Remote Sensing/Geographic Information Systems Analysis**

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I. Overview

The definition of Quasi Formal Homestead Divisions (QFHDs) remains open to debate, in part due to the time-dependent nature of such a phenomenon. The presence and precise location of QFHDs, also referred to as *colonias* in some literatures and areas, is a high priority for water management, housing, environmental and health agencies, among others. The question of detecting QFHDs via remotely sensed data thus is actually a cyclical pair of questions: how can QFHDs be detected without a standardized definition across time and space, and how can a spatially and temporally explicit definition be created until they are adequately described? In other words, this vein of QFHD research requires an iterative process of definition, descriptive work, refinement of definitions, and further detection.

To this end, this analysis took QFHD locations known from surveys and field visits and identified them on high resolution products. Next, the characteristics of the QFHDs as represented on those products was extended to lower resolution products as well as to other areas to look for undocumented QFHDs. The results were mixed, and from this work it is clear that further refinement of the precise definition of QFHDs is critical to obtaining the ancillary products necessary to improving accuracy of detection. Furthermore, it is apparent that an integrated remote sensing/Geographic Information System (GIS) approach is necessary to reliably predict QFHD location, migration, and evolution.

II. Remote Sensing Classification

Classification is the process of taking data and separating them into groups of known identity. For example, a classification for a general map might label each part of the landscape as forest, water, residential, urban, grass, or barren. This work sought to classify current QFHD locations only, although future work may focus on separating QFHDs at different stages of development.

Remote sensing classification is performed using either or both aerial photography and satellite imagery. Historically, air photos were used because their spatial scale was such that structures on the ground could be clearly identified, although the scale is dependent upon elevation of the aircraft relative to the ground and the focal length of the camera. Satellite imagery has been more commonly used since the early 1970s, but often has lower or poorer spatial resolution (i.e., appears more blocky or “zoomed out”). What satellite imagery has to offer as improvement over air photos is 1) increased spectral resolution, meaning a variety of reflectances are used including multiple infrared responses, and 2) a simultaneous broadscale or synoptic view. The choice of product to use largely depends upon the nature of the phenomenon under study. Since little work has been documented in the detection of QFHDs, both products were tested.

III. Aerial Photography

Digital orthophoto quarter quadrangles (DOQQs) were obtained for multiple areas within the state of Texas (Austin, Brownsville, Del Rio, and Killeen), with each set of four representing the area covered by a single 1:24,000 USGS topographic quad. The nominal resolution of the digital photos was 1 meter, one of the highest or best spatial resolution products available. However, the photos were panchromatic (black and white), and thus did not contain multiple reflectance responses or any infrared information. Experienced field personnel easily determined the location of known QFHDs, and the spatial scale of the photos made discriminating QFHDs from other similar objects (e.g., trailer parks) easier than had been hypothesized.

Among the factors used to discern QFHDs were as follows: proximity of location to MSA boundary, orientation of development to road, orientation within area of driveways and access roads, type of road (primary, secondary) that entrance to area was located off of, size and spatial distribution of housing units, and roof materials. Previously undocumented QFHDs were easily detectable but each DOQQ covered only a small portion of an area, and although the data were relatively inexpensive the data volume became an issue. While these data are expected to be available statewide, issues of how frequently (if at all) they will be updated is open to question, and it is doubtful that many researchers or agencies would have the data space to keep all DOQQs accessible at once due to data volume restrictions. Furthermore, very few states have the equivalent of statewide coverage for DOQQs.

IV. Satellite Imagery

In order to try to reduce data volume and storage issues as well as simultaneously increase area coverage, Landsat TM (Thematic Mapper) imagery was acquired of the areas in question at nominal 30 meter spatial resolution and each scene covers an area on the ground that is 170km by 185km. Landsat TM data record seven reflectance responses, three in the visible range and four in the infrared range. Thus these data offer significant improvements over DOQQs in terms of areal coverage and spectral resolution, but at the cost of spatial resolution. The decreased spatial resolution or coarseness of the data rendered visually detecting the known QFHDs extremely difficult, and the detection of potential undocumented QFHDs extremely inaccurate.

Two classifications were run to determine if computer-aided classification based upon multiple spectral responses would improve the results. First, an unsupervised classification was performed to generate multiple statistically significant landcover classes, and those classes then evaluated to see if any corresponded with QFHDs. Second, a supervised classification using the known locations as calibration data was run to try to pull out spectrally similar areas. The first-run results were unsatisfactory; neither the supervised nor unsupervised classifications were useful in locating QFHDs with a high degree of confidence. The unsupervised classification did yield some areas for possible inquiry that could be field or air photo checked, but many of these areas upon further analysis turned out to be strip malls, subdivisions, and trailer parks. The unsupervised classifications did prove more useful in less developed and less heterogeneous and interdigitated areas such as Brownsville and Del Rio as opposed to Austin and Killeen. The supervised classifications for Austin and Brownsville were not statistically significant due to too few training sites input into the model. More training sites were located for Del Rio and Killeen, so those models were statistically significant, but the QFHDs classes were underspecified, meaning that most QFHDs were located successfully but other non-QFHD classes were lumped in with them (an error of commission as compared to an error of omission).

V. Next Steps

From the above analysis it appears that the spatial threshold for discerning QFHDs is under 30 meters, and likely closer to the 5-10 meter range. Statewide coverage is available in 10 meter

panchromatic SPOT imagery, with each scene covering an area 60km by 60km. However, these data also are not currently available in all states. There also exists the possibility of 20 meter resolution multispectral SPOT data (XS), but the cost of these data is currently prohibitive. Yet the problem of using DOQQs remains: the number of DOQQs (and associated data volume) necessary to implement this study across a larger area is beyond the capacity of most agencies and researchers. Furthermore, the ongoing acquisition of such products to allow for updating QFHDs periodically is a cumbersome process unlikely to result in even a five year periodicity of monitoring for larger areas.

The logical path appears to be testing the 10 meter panchromatic satellite imagery while developing two leads that showed promise in this analysis: texture extraction and ancillary information. Texture analysis involves mathematically characterizing the spatial configuration typically exhibited by QFHDs and detecting that pattern rather than a purely spectral response. The use of linear enhancements and pattern metrics will likely increase the accuracy of QFHD detection, but the development of these methods will require a much more precise definition of QFHDs overall and at different stages. Second, the use of ancillary information also aids in the process by eliminating areas not likely to have QFHDs by definition: examples might include urban and shopping centers, or areas not properly located in proximity to the MSA boundary. The development of this approach also depends first upon definition precision and second ancillary data acquisition. A Boolean elimination tool can easily be created to cut out areas within urban centers and well beyond the MSA boundary, further than a specified distance from a major road, etc. But again, the progress of this work is dependent upon the progress of definition clarity: what happens when a QFHD is annexed as recently happened outside Austin? is it immediately no longer a QFHD? Remote sensing and GIS analysis are therefore both helpful and dependent upon the results of two stages of inquiry: more accurately describing what a QFHD is, and detecting that prototype on the landscape.