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Natural and artificial landscape change in a Dutch Estuary: Partially monitored with low budget method (a study in the fourth dimension)

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Abstract: This study includes some aspects of the shift in the Dutch attitude in relation to water during the past millennia from defense to attack to keeping the balance("co-evolution"). It has a special focus on the freshwater tidal part, which embraces the largest seaport of the world: Rotterdam, as well as the largest national park of the Netherlands. It reports especially about a young mans endeavor in half a century real time monitoring of some land(scape) units with simple means.

Keywords: landscape; Dutch Estuary; low budget method; landscape monitoring

1 Methods and scale

Methods of study in the fourth dimension, as in the spatial ones, depend on scale. The main order of magnitude in the fourth dimension are as follows: (1) Hours to days(e.g. tidal movement); (2) Months (10^{-1} year; climatic seasons, seasonal vegetation change); (3) Year to decades(1—10 year, pioneer vegetation succession, initial soil ripening, land use); (4) Centuries(10^2 year sedimentological processes, secular plant succession, soil formation, macro climate, development of culture and technique and related land use); (5) Millennia(10^3 year, soil formation, geo-hydrographic processes); (6) Larger era's of time ($> 10^4$ year), macro geological and geomorphologic processes(sedimentation, plate tectonics, secular erosion)

The main ways of studying the fourth dimension are: (1) infer from side by side occurrence of different development stages in the same point of time; (2) infer from historical spatial data(written documents, maps); (3) infer from vertical stratification(in geological and soil profiles; (4) sequential study in real time and this either: (a) at the same point in space (permanent observation plots; like e.g. PQ) or (b) by sequential mapping in the field preferably in combination with remote sensing of any scale varying from observation from an elevated platform ranging from photography to satellite observation.

This paper deals in particular with a sequential study in real time((a) and (b)) at the scale level from 1 year to a century.

2 The fourth dimension in the Rhine and Meuse Estuary

2.1 The last millennia

Defense by dikes, embankment, dredging and drainage has been for ages the traditional attitude towards the sea and the rivers in the Netherlands. The landscape of the Rhine and Meuse Estuary embracing the largest national park of the Netherlands "Biesbosch" as well as the biggest sea port of the world: Rotterdam, has been developed the last millennia under influences of this attitude. As most of the large river delta's of the world the combined delta of Rhine, Meuse and Scheldt, which embrace almost the total of the lowlands called the Netherlands(including "Holland"), are subject to relative descending land in relation to the sea level. For the situation in our study area it can be stated that: The elevation of the land surface in relation to the water level depends on (1) movement of absolute sea level; (2) river discharge; (3) shape of coastline and/or estuary; (4) rise and fall of the land surface by (a) isostatic movement of the earth crust, (b) tectonic movement, (c) speed of accumulation of mineral and organic matter, (d) subsidence by shrinkage and decomposition of soil material.

The relative rise of the sea level, mainly due to the refilling of the ocean since the end of the last glaciations, and isostatic movement of the from an ice load freed earth crust, was since the coast line approached the present contours of the Netherlands, little less then twenty meters and is still continuing. The sedimentation of Rhine, Meuse a Scheldt however could, within the contours of the present Netherlands counteract the subsidence of not yet embanked land. The result was a landscape with an in

time and space-varying character from relative dry too marshy and peat land. It became during the last four to five millennia habituated by farmers at the higher terraces and fisherman and hunters along the rivers in the more peaty and marshy places. The increase of population and first activities to combat the water by drainage(causing shrinkage and subsidence) and the discovery of the use of peat as fuel as well as source of salt(from by seawater flooded peat deposits) resulted in a period of serious devastation during the early middle ages. Absolute sea level in combination with absolute land subsidence as well as irresponsible mismanagement worked hand in hand until technology gradually could restore the balance in a certain way. Large areas were concurred back from the sea. The famous Dutch polder landscapes were the result. The pattern and process can be followed and dated by the study of the geological profiles in mineral and organic deposits from this period and for the last period also by soil survey and written historical documents including maps. The results of these are demonstrated during the presentation.

The increase of technology caused a gradual shift of the balance between artificial (technological) and natural forces towards the first. The culmination of the primate of the artificial happened during the last half of the 20th century with the closing of some main estuary branches and the further narrowing down of the not yet embanked parts of the river floodplains. During the whole process the level of land surface, compared with the sea, shows variations resulting in a stratification of different mineral and organic deposits. This variation did not stop after the increase of the influence of man. The history(also the more recent part) of the Netherlands is a story of sequential flood disasters. These show an increase in severity, as the higher the dikes become as well as deeper the drainage(hence shrinkage) is, the more intense the disaster, in case the dikes still collapse. It appeared that the balance between nature and culture became more and more surpassed. This lead recently(in the beginning of the present century/millennium) to a break in the Dutch altitude. The Dutch government proclaimed the doctrinal of "space for the river", recognizing that the trimming of the natural forces of river and see had gone to far. The era of land reclamation on sea and river ended and even partial "de-poldering" started. This means, a breaking point in the Dutch cultural and natural (landscape ecological) history.

2.2 The last centuries in the freshwater tidal part

It happened that during that last half century(starting in 1948) still before the general acceptance of, the surpassed balance between culture and nature, a young student, not yet aware of the approaching historical change, had chosen a part of the Rhine/Meuse Estuary as study area for his MSc in ecology, focused on landscape dynamics. His entrance was the (changing) pattern of the landform and vegetation in the freshwater part of the estuary. This pattern based study became the base of the development of his landscape-ecological thinking, later extended over the main landscapes, of the world. As in those days no budged was available and he more over already then decided for a long period of time, he chose simple means for "remote sensing" of a limited part of the area with as observation platform the top of an ordinary 55 meter high tension line pylon. This resulted sequential (yearly) sketches, later followed by oblique photographs from the pylon and occasionally sketches and observations in the field. The data include species composition, soil and elevation. Also the latter was measured by a low budged- one-man-method, using "sticks with cups" which simply could recorded every individual flood compared with the same device on a fixed point(the plan base) that could be averaged after many measurements to MHW(mean high water level). After his MSc he got the official order to map(then still as a base for further embankment) a larger part of the freshwater tidal area.

He decided however from the beginning on to privately continue, as a kind of hobby work, at least until his retirement, the low budget monitoring taking no more time then a few days/year. The total monitoring period became just half a century and so lasted till about ten year after his retirement and even continues to the present day. The final result of the first half century, accumulated in a final publication end 1999 in which also other data collected in permanent observation plots scattered over a larger area (some preliminary publications date from 19(59)60 and 1975). It presents description of the sedimentological development in close relation to the behavior(strategy) of plant growth and "extension waves" of various plant species including(for estuaries characteristics) neophytes, also in terms of vegetation and life form types. The yearly oblique photographs were interpreted and converted in to a series of about fifty oblique land unit maps and(as after half a century finally a budged became available) with

help of modern GIS means, each represented the same scale. As the observation angle deviated relative far from the vertical and the quality of the used simple cameras was not optimal, it appeared less efficient to rectify the oblique's to verticals for doing measurements. As however distances on lines parallel to the horizon on oblique photos do not give distortion, these were used to measure vegetation/ land unit patterns.

The composition and pattern of registrated landform and vegetation changes expresses clearly the influence of the mentioned closure of the estuarial branch that occurred just halfway the observation period. Vegetation and soil data show that, even in the dynamic estuarine environment, an ecological shock may have a lag period up to a quarter century.

The ecological influence of change in tidal movement is for a main part operational via the soil (groundwater and initial soil ripening). Waves of giant neophytes characterize the lag period as well. The in real time followed developments show in the small time scale similar aspects in the balance of silting up and subsidence by shrinkage as in the millennial developments. The data on vegetation change are a base for prediction the development of vegetation in the areas were "depoldering" will take place as well as of the effect of the reentrance of a larger tidal movement as result of the opening up the sluices. So, together with many other data the results are being used in scenario building and in this way contributes also to the development of ideas about the shifting balance mentioned above between technology and nature and the need to restore original estuarine nature. One aspect is the creation of a national park instead of new polders in the freshwater part of the estuary that, among the various functions of any other national park, plays a role in keeping the balance in the Dutch water management policy.

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