Dust storms and rural development in North China

Fratini* G., Da Canal S., Valentini R.
Department of Forest Science and Environment
University of Tuscia, 01100 Viterbo ITALY

* Corresponding author : gfratini@unitus.it

Introduction

Dust Storms, are one of the most astonishing and scaring manifestation of earth's power. These extreme meteorological events originate in the big deserted areas of the world and are characterized by huge amounts of high-concentration dust particles transported at high speed by winds

As a natural phenomena, Dust Storms plagued the planet all over the history; nonetheless, there are raising evidences that anthropogenic disturbances are affecting the delicate deserts ecosystems in a way that is leading to an increase, in frequency and intensity, of these events.

The main direct human threats are related to overexploitation of natural resources: livestock over-grazing, intense agriculture, extraction activities, trees cutting for firewood leave loose, dusty soils, easily subject to wind erosion. Indirect human impacts are related to overexploitation of water, that leads to partial or complete drying up of water basins and exposure of erodible soils to the wind action; finally, enhancement of desertification processes is also an overall consequence of the global changes induced by human activities.

By this point of view, dust storms are a *symptom* of the desertification, but they are a *cause* of desertification as well. Indeed, sand transported at high speed by winds plagues the lands on its path, burying agricultural and range-lands as well as water courses, thereby enhancing the desertification processes, particularly in lands already threaten by intense human activities. On the local scale, another problem is related to the *dune shifting*, that can lead to a dune displacement of even 1-2 m/day, depending on the wind power. Such dunes invade roads, threat buildings and infrastructures, and cover entire vegetated lands, thus enhancing the desertification.

"Dust" here refers to fine particulate, with diameters ranging from 0.1 to 100 micrometer, thus involving fine sand particles; the finest components of this dust (PM10) are lifted up by wind and transported over long distances at the continental scale; they contribute to the global dynamics, acting as an aerosol, reducing the solar irradiation at the ground, indirectly contributing to global climate changes.

At the same time, under the influence of global climate change, warm winters and dry springs occur more seriously in the arid regions were large areas of vegetation are impacted. It causes serious water and soil losses, secondary salinisation and deterioration of the physical structure of the soil and hence amplifies the effect of wind erosion.

Dust Storms are a direct threat for human health as well: during the storms and for several days later on, fine particulate matter is suspended in the air; when breathed by men and animals it creates severe problems to the respiratory system. This problems are not limited to the regions where the storms arise. For example, storms originated in the Gobi desert, rapidly move eastward, reaching the great megalopolis of Eastern Asia, like Beijing, Tokyo, Pyongyang, bringing the same problems of health risks to millions of people; indeed, the *China Environmental Monitoring Centre* showed a correlation between sand storms and the increase of the Total Suspended Particles, TSP, in the towns downwind the sandstorms origin regions [3]. The typical dimension of the suspended particles are inversely proportional to the distance from the sand storm source. Concentration of the smaller fractions (PM10 and PM2.5), is increased 4-5 times the normal concentration and it is known to be responsible for the worst effects on human health [2]. During sand storms, visibility is

also reduced to few meters or even less, disturbing terrestrial and aerial traffics, and dramatically increasing risks of accidents.

The situation in North China

Sand Storms sporadically appear all around the world, mainly in the big deserted areas of North Africa, Middle East, North US, Australia and particularly in Central Asia, where China is one of the countries more severely plagued by desertification. With up to 58% of the country's land area being classified as arid or semi-arid, nearly one-third of China's land suffers the effects of desertification and is responsible for the biggest dust storms in the world [1].
The deserted areas of Inner Mongolia, and in particular of the Alashan Prefecture, are supposed to be one of the most intense sources of dust storms of the world. All along the year, and mostly in spring, strong and persistent winds blow from Siberia and insist on the lands of Gobi region; springtime is also the driest period of the year, when most part of the lands are naked and the lack of humidity makes soils even more susceptible to wind erosion. The contemporary presence of such factors leads to the formation of the most powerful, scaring and destructive dust storms of the world.

The finest components of the lifted materials are transported through the atmosphere, until North Corea and Japan, sometimes reaching the US West Coast.

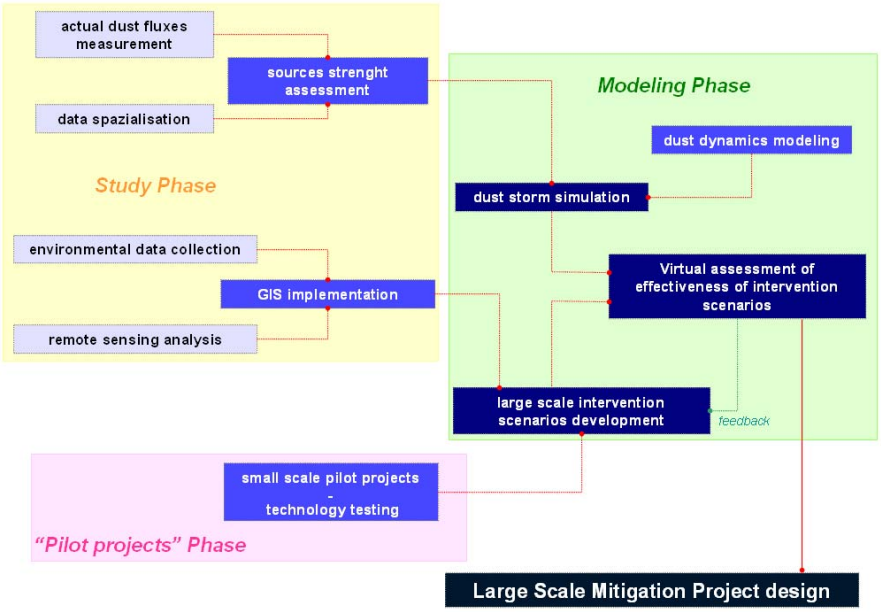
A step toward control of Dust Storms

As already recognized by UNCCD, "[..] There is a need to document the nature, extent, causal factors associated with the severe sand and dust storms experienced in China and to look for methodologies to face them [..].Combating sand and dust storms demands political, social, biological, economic, educational and engineering approaches as well as the physical effort that has dominated efforts in the past." [1].
As a step toward the comprehension and the fight against Dust Storms, the Environmental Protection Bureau (EPB) of Beijing Municipality and the Italian Ministry for Environment and Territory (IMET) are promoting an ambitious project named WINDUST, which also contributes to the main scope of the United Nation Convention to Combat Desertification (UNCCD).
The project is located in the Alashan Prefecture (Inner Mongolia); this is an arid and semi-arid plateau where the continental climate and the distance from the see bring cold and dry winters and warm and relatively humid summers (rainfalls rarely exceed 150 mm/year). Population living in the region is sparsely distributed, mainly constituted by shepherds breeding goats, sheep, horses and camels; population typically lives in family farms, fed by subsistence agriculture.

The *rationale* of WINDUST project is to propose and test methodologies of intervention aiming at preventing and mitigating Dust Storms impacts.
The distinctive idea characterizing the project is to joint scientific research, experimentation and practical implementations for rural development into an integrated effort of cooperation and mutual exchange, in order to develop and propose a comprehensive and participatory methodology rather than "a single solutions for a single problem". It should be of the most importance: due to the unstable equilibrium governing environment and socio-economy in those critical regions, dealing with desertification and wind erosion can only be effective if carried on with an integrated approach, taking into account all the consequences and the possible feedbacks of any action.
Far from being only an "environmental" project, WINDUST has been thought to introduce the concept of sustainable development in the rural areas of Alashan, limiting human pressure on

natural resources, thus leading to prevention of anthropogenic enhancement of dust storms and mitigation of natural causes.

Due to substantial lack of knowledge about the phenomena involved, the enormous dimensions of the problem and the extreme environmental conditions of the concerned region, several objectives has to be reached in order to assess feasibility and reliability of any prevention/mitigation action: first of all, knowledge about the processes and their interrelations has to be significantly improved and systematise, strengthening the efforts of the scientific community in this direction; effectiveness and reliability of technologies and methodologies have to be assessed, as well as people degree of acceptance of such technologies; furthermore, an integrated intervention approach should be proposed in order to take into consideration the multidisciplinary nature of the topic.
To achieve this goals, the WINDUST project is structured in three conceptual phases, as sketched in Fig.1: a *study phase*, *a "pilot projects" phase* and a *modeling phase;* joining the outputs of this three packages leads to the final *large-scale intervention planning phase.*



Fig, 1 - *Logical scheme of WINDUST project*

The study phase
In this starting activity, any available information concerning the environment and the socio-economic features of the region will be collected and integrated in a comprehensive database. A complete GIS of the case-study region, located in the eastern district of Alashan, will be compiled. All the information about the structure of the society will be included in a report, possibly integrated with *in situ* interviews to local population and regional authorities.
The main activity linked to this assessment phase is the development and testing of an innovative technique to measure dust emission caused by wind erosion. Based on the so called "eddy covariance" methodology, this new technology will help putting some light on the dynamics associated with the erosion processes; furthermore, it will be one of the first attempts to directly quantify the actual amount of matter emitted during the erosion events; when used on a large scale, this would be of great help in focusing the intervention strategy in the most critical areas.

The "pilot projects" phase

Human activities are known to be one of the harming factors enhancing dust storms. For this reason, any "environmental" action dealing with desertification has to be a "social" action as well. Introducing the concept and the pragmatism of "sustainable development" is thus mandatory, in order to both reduce anthropogenic impacts and *use* human activities to fight problems, instead of creating them.

By this point of view, several pilot projects has been proposed to test effectiveness, reliability and potentiality of innovative agriculture technologies and methodologies.

State-of-the-art Italian methods will be joint to traditional practices, in order to gradually turn local economy toward a sustainable one, while mitigating and preventing dust storms.

Low-energy, low-water demanding soil working technologies (e.g. irrigation by wind water pumps and the so-called "Vallerani System") will be tested, to assess the possibility to use re-vegetation (including afforestation/reforestation) as a large scale action to contrast wind erosion.

Clean, renewable energies (basically wind and solar) will be used to supply both traditional cultivations and *new-concept nurseries* of local species (mostly *Saxaoul* and *Artemisia*). While helping alleviating wood demand for house warming (thereby reducing pressure on forest resources), *high efficiency burners* will significantly reduce indoor pollution due to combustion residues. Introduction of alien species suitable to local climatic and environmental conditions will be evaluated, as well as enhancement of traditional cultivation with market potentialities (e.g. *ginseng* cultivation).

The set up of the pilot projects has been inspired by the a participatory approach; indeed, each activity has to be implemented and carried on by teams composed of Italian experts, local experts and local population: the families (including women and youths) will be involved in all the phases of the project, maintenance of infrastructure will be up to the farmers and for this reason training courses for the "high"-tech introduced will be planned. The underlying idea is to make the foreign presence unnecessary in the management phases of the projects.

The "modeling" phase

The pilot projects are intended to test *local* effectiveness of several mitigation/prevention interventions; indeed, the dimension of the source region makes any small scale project ineffective in reducing the total dust emission. Quantitative measures of dust emission are also "punctual" information, that need to be extended at a regional scale, in order to be useful.

This is why a "modeling phase" has been introduced in the project as a necessary step toward a large scale intervention plan. An integrated model , based on remotely sensed images of the region, on the measures of actual dust emission and on process-based schemes, will allow simulation of the so-called *dust cycle* (production, suspension, transport, deposition). By virtually simulating the impact of possible scenarios of intervention, such model will be of great support in planning large scale action to broadly use the most effective and reliable technologies tested in the pilot projects phase.

The overall project has be designed and will be developed by a consortium made up of governmental institutions, universities, public and private research centres, private manufacturers and agencies, both Italian and Chinese. Such a variegate team is needed to face tasks spanning from theoretical modeling to soil working, the success of the project been strictly linked to a continuous interface and cooperation between the parts and to a balanced importance given to all the components.

Dust storms are not a challenge that can be faced and resolved in few years; nonetheless, such a multidisciplinary project could be an important kick-off and a point of reference for future mitigation and prevention actions, showing the benefits and the limits of an action aiming at controlling such a big environmental problem.

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