# Economic assessment of environmental impact in the course of oil field development and production

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**Abstract.** The article considers the variety of impacts that oil exploration and production operations have on the environment at different stages of the process. To provide accurate economic assessment, an oil field development project was designed, with various development options. These options being analyzed, the strategy with the minimal environmental impact was identified. This has allowed preparation of a guideline on how to prevent deterioration of the environment and to reduce the negative environmental impact

## 1. Introduction

Economic growth and success depend on both natural resources management and the intention to reduce the negative impacts caused by implementing development projects [10]. This can be achieved by careful project selection and improvement of project management, i.e. planning, design, and implementation [8]. Environmental impact assessment (EIA) includes two stages. The first stage is determining and measuring the environmental impact, the second one is calculating monetary value, which is necessary for further economic analysis [4]. Intensive industrial development over the past years exacerbates ecological problems, namely pollutant emissions, smoke, accumulation of industrial wastes. This causes ecological imbalance in the territory of the region, which has a negative impact on human health [5]. Economic assessment of the environmental impact is based on studying and measuring biophysical changes caused implementation of a certain project.

The main objectives of environmental impact assessment used for oil field development and production are determination of economic, ecological, and social impacts caused by different field development options; setting guidelines to minimize the negative environmental impact and to prevent environmental degradation [2]. Potential environmental impacts of the project activities while field development and production are as follows: air pollution, destruction of habitat, surface and ground water contamination, soil contamination, soil and ground disturbance.

To prevent pollution, environment protection measures should be taken in the area of oil field development and production.

## 2. Materials and Methods

In our research, environmental impact assessment (EIA) was made for the oil field located in Kargasok region, Tomsk Oblast. The Upper-Jurassic formations of the field are at the depth of 2625 m.

The calculation was made for each component of the environment with the application of the relevant calculation methods [6].

## 3. Results and Discussion

The oil field development will have negative environmental impact on the atmosphere, flora and fauna, lithosphere and terrain, hydrosphere, and natural resources. The negative impacts are caused by constructing well pads and access roads; well drilling, cementing, completion; testing; well performance; welding, painting, and coating; leakages and accidents (pipeline failures, oil, gas, and water showings); well abandonment.

Mechanical impact is a challenge of major concern because of heavy trucks and construction machines which cause soil, plants, and water contamination. The operations performed by the machines and vehicles result in mechanical disturbance of soil and subsoil, destroying soil structure, mixing of soil layers [7], and negative impact on soil fertility. In the result, biological characteristics of the soil change to the worse and the biological toxicity increases [1]. Chemical contamination by oil products, drilling muds, and cementing slurries is an inevitable consequence of bund failures and poor pit tightness, as well as mud pit overflows. Pollution potential of the drilling mud is determined by the oil product content, surface active substances (surfactants), heavy metals etc. Oil spills have the most dangerous and long-term effects. The rate of contamination is determined by the depth of oil penetration, the amount of oil, and mechanical properties of subsoil.

In the process of oil field development, hydrogeological properties of the formation change significantly, as well as those of shallow aquifers of fresh groundwater do. The changes within the formation are caused by the recovery of reserves within production zone. This decreases the formation pressure and causes water coning and fingering. The latter is the reason for the chemical composition of the water to change.

Taking into account all factors, types, and sources of pollution mentioned above, three alteration projects of oil field development and production have been considered. Each of the projects involves drilling 66 wells.

Project 1 details: one drilling crew, which drills 12 wells per year over the period of 5.5 years; constructing a modular cluster pump station (MCPS); drilling a well for water supply up to Cenomanian strata; constructing an oil treatment unit, a compressor and a gas dehydration unit. Gas flaring does not take place. The gathering pipeline stretches from the modular cluster pumping station to the oil treatment crossing the river and is constructed using the trenchless horizontal directional drilling (HDD) technique.

Project 2 details: two drilling crews, which drill 24 wells per year over the period of 2.8 years; constructing two MCPSs; constructing an oil treatment unit, a compressor and a gas dehydration unit. As in the case of Project 1, the gathering pipeline between the MCPSs and the oil treatment unit crosses the river and is constructed using HDD.

Project 3 details: one drilling crew, which drills 12 wells per year over the period of 5.5 years; drilling a well for water supply up to Cenomanian strata; constructing a MCPS; constructing an oil treatment unit, a compressor, and a gas dehydration unit; constructing flares as 5% of gas is flared. The gathering pipeline stretches from the MCPS to the oil treatment unit crossing the river and is constructed using conventional trenching technique.

Project 1 is considered the most appropriate because of the following advantages. The rate of the environmental impact caused by Project 1 implementation is less than that of Project 2. The amount of water recovered per year from the Cenomanian aquifer is less, as well as the rate of air pollution because the amount of emissions caused by two MCPSs is twice as much as that caused by one. Moreover, the more water is pumped into the formation, the more significant the changes are in the chemical composition of the formation fluid. When the stage of drilling is completed, the second MCPS is out of use, therefore Project 1 is more preferable than Project 2 in terms of economy as well.

Project 1 is also more appropriate than Project 3. Gas flaring will have negative atmospheric impact as more pollutants are emitted into the air. When the pipes are lowered into the trenches, the banks of

the river will be destroyed and a lot of river creatures die. If there are any pipeline failures, petroliun products will get into the river, which poses a deadly threat for both river creatures and the animals whose habitat includes the banks of the river [3]. In terms of economy, trenches are cheaper than HDD technique, but one should take into account the additional costs for flares construction and the payment for gas flaring. As a result, if one considers the whole life cycle of the field, Project 1 is the most effective.

Economic assessment of the environmental impact includes the payments for the negative atmospheric impact over the period of the field development and production calculated for three designed facilities: a diesel power station, welding and painting units, and a steel vertical stock tank. The total is 2674852.203 rubles.

All wastes produced over the project implementation can be split into industrial wastes (cuttings) and municipal solid wastes (MSW). The industrial wastes are supposed to be accumulated within a special place in the territory of the field and then transported to the industrial waste disposal site once every three months. While the wastes are in the territory of the filed, they have the negative impacts on the atmosphere (as they contain volatile substances), surface and ground waters, soil.

The payment for accumulation and transferring the wastes to the disposal site over the period of drilling is 212256157.4 rubles. MSW are packed in special containers, which are transported to the MSW recycling site and the payment over the period of the field development is 1555533.92 rubles.

The Project implies pumping water into the formation to flood oil towards production well and maintaining the pressure. For these purposes, the water supply well will be drilled up to Cenomanian strata. The water will be supplied from this source over the whole period of the field production, which is 39 years. The Project also implies construction of oil treatment unit, where the water is treated and desilted before being pumped back into the formation. This provides water circulation and the amount of Cenomanian water recovered decreases every year. The implementation of circulation system allows reducing the negative impact on underground waters of Cenomanian strata and cutting back on water tax. The artesian water for the domestic use will be supplied from another well also drilled in the territory of the field.

The total amount of water tax adjusted for the inflation over the period of the oil field development and production is 6077487 rubles.

From the oil treatment unit, the main pipeline stretches to the nearest oil field. Within the Project, the most probable pipeline accident was designed, i.e. pipeline break because of the intensive corrosion. If the amount of oil at the pipeline inlet were 400 tons per day, the repair services took an hour, the amount of oil leaked would be 16.7 tons. The accident would extend throughout the forests and marshes, the oil would get into bog lakes avoiding the rivers. In this case, the maximum probable payment for the negative environmental impact including that on the forests is 4033594.87 rubles.

The total amount of payments for the negative environmental impact, water tax, and transferring wastes to the disposal site over the period of the field development and production is represented in table 1.

**Table 1.** Negative environmental impact over the period of the field development and production.

| Sphere | Environmental Impact | Amount of Payment, rubles |
|---|---|---|
| Atmosphere | Air pollutant emissions | 2674852.203 |
| Hydrosphere | Water tax adjusted for inflation | 6077487 |
| Lithosphere | Accumulation and transferring of industrial and municipal solid wastes to the disposal and recycling sites | 213811691.3 |
| Accident | Negative environmental impact | 4033594.87 |
| Total, rubles | | 226597625.4 |

The payment for the negative impact on the lithosphere makes up about 94%, which results from the number of wells and the periods of drilling and production.

Alongside with the impacts mentioned above, the consequences of the project implementation will be reduction of natural habitat, destruction of mineral metabolism, destruction of plants, deforestation, decrease in the population of animals, noise and vibration impacts. However, within the Project, these impacts are not assessed and neither are ecosystem services [9]. EIA project is the calculation of costs for oil field development and exploration and is not regarded as a financial instrument to compensate for the negative environmental impact, stimulate the companies to implement efficient resources management and minimize the project effects on the environment.

## 4. Conclusion

Reflecting on the facts represented above, we arrive at the following conclusions:

– the atmospheric impact might be evaluated as over-limit because no research has been conducted to set the limits (for more accurate analyses, maximum allowable concentration should be calculated);
– the impact on lithosphere, hydrosphere, and fauna is evaluated as acceptable;
– the impact on flora over the periods of field development and exploration is evaluated as moderate; when the well is abandoned, vegetation is recovered;
– social and economic impacts are positive for the development of the local economy, however, the major part of ecosystem services is not considered.

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