SOI: 1.1/TAS
DOI: 10.15863/TAS
Scopus ASJC: 1000

ISSN 2308-4944 (print)
ISSN 2409-0085 (online)

№ 02 (130) 2024

Teoretičeskaâ i prikladnaâ nauka

Theoretical & Applied Science

Philadelphia, USA

Teoretičeskaâ i prikladnaâ nauka

Theoretical & Applied Science

02 (130)

2024

International Scientific Journal
Theoretical & Applied Science

Founder: **International Academy of Theoretical & Applied Sciences**

Published since 2013 year. Issued Monthly.

International scientific journal «Theoretical & Applied Science», registered in France, and indexed more than 45 international scientific bases.

Editorial office: http://T-Science.org Phone: +777727-606-81

E-mail: T-Science@mail.ru

International Scientific Journal
Theoretical & Applied Science

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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 03.02.2024 **http://T-Science.org**

Issue **Article**

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AIR POLLUTION BY ROAD TRANSPORT IN TASHKENT

Abstract: *The article is devoted to the problem of atmospheric air pollution using the example of Tashkent. The priority substances that pollute the city's air and their impact on public health are identified.*

Calculations of the content of pollutants in the air were carried out and criteria for the formation of dangerous concentrations (smog) near highways were determined. The main parameters of the influence of natural and anthropogenic factors on the level of atmospheric pollution have been identified. The article presents the results of studies of the state of atmospheric air for the content of fine suspended particles PM10 and general dust, as well as other pollutants, conducted in the city of Tashkent. Recommendations are given to reduce air pollution.

Key words: *atmospheric air, atmospheric pollution, emissions of harmful substances, road transport, environmental pollution, atmosphere, dust, PM10.*

Language: *Russian*

Citation: Shadimetov, Yu. Sh., Ayrapetov, D. A., & Niyazov, X. P. (2024). Air pollution by road transport in Tashkent. *ISJ Theoretical & Applied Science, 02 (130),* 1-9.

Soi: http://s-o-i.org/1.1/TAS-02-130-1 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.02.130.1

Scopus ASCC: *2303.*

ЗАГРЯЗНЕНИЕ АТМОСФЕРНОГО ВОЗДУХА АВТОМОБИЛЬНЫМ ТРАНСПОРТОМ В ГОРОДЕ ТАШКЕНТЕ

Аннотация: *Статья посвящена проблеме загрязнения атмосферного воздуха на примере г. Ташкента. Выделены приоритетные вещества, загрязняющие воздушный бассейн города и влияние их на здоровье населения.*

Проведены расчеты содержаний загрязняющих веществ в воздухе и определены критерии формирования опасных концентраций (смог) вблизи автомагистралей. Выявлены основные параметры влияния природных и антропогенных факторов на уровень загрязнения атмосферы. В статье приведены результатах исследований состояния атмосферного воздуха на содержание в нём мелкодисперсных взвешенных частиц PM10 и общей пыли, а также других загрязняющих веществ, проведённых в городе Ташкенте. Даны рекомендации для снижения загрязнения атмосферного воздуха.

Ключевые слова: *атмосферный воздух, загрязнение атмосферы, выбросы вредных веществ, автомобильный транспорт, загрязнение окружающей среды, атмосфера, пыль, PM10.*

Введение

Проблема загрязнения воздуха в городах представляет собой сложный набор аспектов. Она затрагивает вопросы, связанные с заболеваемостью населения, негативным воздействием на флору и фауну, а также общей ухудшающейся экологической обстановкой в городских районах.

Под термином "загрязнение атмосферного воздуха" понимается любое изменение его состава и характеристик, которое оказывает негативное воздействие на здоровье людей и животных, а также влияет на состояние растений и экосистем [1].

Загрязнение атмосферного воздуха имеет разнообразное происхождение, подразделяясь на естественное и антропогенное [2]. Естественное загрязнение связано с природными процессами, такими как вулканическая деятельность и выветривание горных пород. В свою очередь, антропогенное загрязнение обусловлено воздействием человека и включает выбросы разнообразных загрязняющих веществ. Важно отметить, что масштаб антропогенного загрязнения существенно превышает естественные процессы. Антропогенное загрязнение может проявляться в различных формах: местном, региональном и глобальном. Местное загрязнение характеризуется повышенным содержанием вредных веществ на ограниченной территории, например, в городе. Региональное загрязнение охватывает более обширные пространства, но не имеет глобального воздействия. Глобальное загрязнение связано с общим изменением состава атмосферного воздуха, вызывая экологические изменения на планетарном уровне [3].

Человеческий организм постоянно подвергается воздействию разнообразных вредных факторов, происходящих из окружающей среды. Взаимосвязь между заболеваемостью и смертностью с состоянием экологии длительное время наблюдается, особенно в индустриальных городах [4,5].

Согласно результатам медико-экологических исследований, загрязнение окружающей среды представляет опасность для здоровья человека. Это подтверждается:

- частыми жалобами жителей, проживающих в зоне загрязненной окружающей среды, на неприятные запахи, головные боли, общее недомогание и другие негативные состояния;
- данными медицинской статистики, указывающими на увеличение заболеваемости на территориях с высоким уровнем загрязнения;
- результатами специальных научных исследований, направленных на выявление количественных связей между загрязнением окружающей среды и его воздействием на организм [6]. Следовательно, оценка загрязнения атмосферного воздуха и его влияния на здоровье становится одной из ключевых проблем.

Автомобильный транспорт выступает как значительный источник выбросов вредных веществ в атмосферу. Резкое ухудшение экологической обстановки в крупных городах, связанное с увеличением интенсивности движения и формированием специфических климатических условий, делает неотложной задачу разработки технологии оценки загрязнения атмосферы и его динамики. Доля вклада автомобильного транспорта в загрязнение атмосферы продолжает расти, особенно в крупных городах, где она составляет 80% и более [7,8].

К основным токсичным выбросам автомобилей относятся: отработавшие газы, картерные газы и топливные испарения. Выпуски отработавших газов, выбрасываемых двигателем, включают оксид углерода (CO), углеводороды, оксиды азота, бензапирен, альдегиды и сажу. Сажа, оксид углерода, углеводороды и альдегиды являются основными токсичными веществами, образующимися в результате неполного сгорания [9,10].

Технология оценки загрязнения атмосферы автомобильным транспортом основана на совместном анализе интенсивности выбросов выхлопных газов и характеристик их перемешивания с чистым воздухом. Интенсивность выбросов зависит от трафика, в то время как активность перемешивания определяется скоростью и направлением ветра [11].

Среди факторов, влияющих на выбросы, можно выделить: общее количество автомобилей, типы и возраст автомобилей в регионе, долю автомобилей различных экологических классов, количество грузовых автомобилей, состояние и ширину дорог, качество топлива, его соответствие экологическим стандартам Евро и другие [12,13]. Значительное воздействие на формирование опасного загрязнения атмосферы оказывает плотность застройки вдоль автомагистралей.

Несмотря на постепенное обновление автопарка автомобилями более экологически чистых 4-го и 5-го классов, доля автотранспорта с низкой экологической эффективностью 0-го класса остается высокой.

Исследования состояния атмосферного воздуха на содержание в нём мелкодисперсных взвешенных частиц PM10 и общей пыли [14], а также других загрязняющих веществ (диоксид азота, диоксид серы, сероводород, оксид углерода, аммиак, фенол) были проведены 13 сентября 2023

года специалистами, Министерство Экологии, охраны окружающей среды и изменения климата Республики Узбекистан Ташкентская городская управлении. Отдел мониторинга, изменение климата и борьба с опустыниванием окружающий среды (аналитическая лаборатории). Наблюдения проводились с помощью прибора (Эколаб) экологической лаборатории.

Результаты проведённых исследований представлены в таблице № 1. Оценка состояния атмосферного воздуха осуществлялась в соответствии с СанПиНом РУз №0293-11 «Гигиенические нормативы. Перечень предельно-допустимых концентраций (ПДК) загрязняющих веществ в атмосферном воздухе населённых мест на территории Республики Узбекистан».

Таблица №1

№ п/п	Место отбора, координаты	Время отбора	Наименование ингредиента	Температура °С	Давление, мм.рт.ст.	Максимально разовая концентрация загрязняющего вещества, мг/м^3	ПДКм.р мг/м^3	Превышение ПДКм.р.
1	Точка №1 Координаты N41.263207, E 69.222420 (Чиланзарский р-н,) перекресток Малая кольцевая дорог	12^{40}	PM10	30	725	0,0063	0,5	
			Пыль			0,0091	0,5	
			Диоксид азота			0,01	0,085	
			Оксид углерода			7,0826	5	1,4
			Диоксид серы			0	0,5	
			Аммиак			0,0032	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0046	0,008	
2	Точка №2 координаты N41.263335, E 69.222527 (Чиланзарский Р-н,) перекресток Малая кольцевая дорога и прилегающая территория	12^{45}	PM10	30	725	0,0063	0,5	
			Пыль			0,0091	0,5	
			Диоксид азота			0,0098	0,085	
			Оксид углерода			6,1040	5	1,2
			Диоксид серы			0	0,5	
			Аммиак			0,0028	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0045	0,008	
3	Точка №3 координаты N41.270025, E 69.211592 (Чиланзарский Р-н,) перекресток Малая кольцевая дорога	12^{50}	PM10	31	725	0,003	0,5	
			Пыль			0,0032	0,5	
			Диоксид азота			0,0078	0,085	
			Оксид углерода			2,0813	5	-
			Диоксид серы			0	0,5	
			Аммиак			0,0067	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0038	0,008	
4	Точка №4 координаты	12^{55}	PM10	32	724	0,001	0,5	
			Пыль			0,001	0,5	

	N41.269344, E 69.212323 (Чиланзарский Р-н,) перекресток Малая кольцевая дорога и прилегающая территория		Диоксид азота			0,0024	0,085	
			Оксид углерода			2,1290	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0005	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0034	0,008	
5	Точка №5 координаты N41.288391, E 69.229625 (Чиланзарский Р-н,) перекресток Малая кольцевая дорога и прилегающая территория	13^{00}	PM10	32	724	0,0009	0,5	
			Пыль			0,0011	0,5	
			Диоксид азота			0,0028	0,085	
			Оксид углерода			1,2564	5	
			Диоксид серы			0	0,5	
			Аммиак			0,001	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0038	0,008	
6	Точка №6 координаты N41.288352, E 69.229187 (Чиланзарский Р-н,) перекресток ул.Мукимий	13^{05}	PM10	32	724	0,003	0,5	
			Пыль			0,003	0,5	
			Диоксид азота			0,0022	0,085	
			Оксид углерода			1,7548	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0036	0,008	
7	Точка №7 координаты N41.288282, E 69.228998 (Чиланзарский Р-н,) перекресток ул.Мукимий и прилегающая территория	13^{10}	PM10	32	724	0,005	0,5	
			Пыль			0,0062	0,5	
			Диоксид азота			0,0031	0,085	
			Оксид углерода			1,2780	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0032	0,008	
8	Точка №8 координаты N41.291013, E 69.225322 (Чиланзарский Р-н,)	13^{15}	PM10	33	723	0,0054	0,5	
			Пыль			0,0065	0,5	
			Диоксид азота			0,0046	0,085	
			Оксид углерода			1,2160	5	

	перекресток ул.Мукимий и прилегающая территория		Диоксид серы			0	0,5	
			Аммиак			0,0022	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0038	0,008	
9	Точка №9 координаты N41.296315, E 69.216591 (Чиланзарский Р-н,) перекресток ул.Мукимий Спорт товары	13^{20}	PM10	33	723	0,0066	0,5	
			Пыль			0,007	0,5	
			Диоксид азота			0,0048	0,085	
			Оксид углерода			3,3403	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0021	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0043	0,008	
10	Точка №10 координаты N41.296396, E 69.216792 (Чиланзарский Р-н,) перекресток ул.Мукимий Спорт товары и прилегающая территория	13^{25}	PM10	34	723	0,0065	0,5	
			Пыль			0,0072	0,5	
			Диоксид азота			0,0073	0,085	
			Оксид углерода			3,5890	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0041	0,008	
11	Точка №11 координаты N41.327935 E 69.283311 (Юнусабадский р-н,) А.Темура Метро Минор	13^{50}	PM10	36	724	0,004	0,5	
			Пыль			0,0047	0,5	
			Диоксид азота			0,0254	0,085	
			Оксид углерода			2,3101	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0005	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0043	0,008	
12	Точка №12 координаты N41.328314, E 69.283546 (Юнусабадский Р-н,) ул. А.Темура и прилегающая территория	13^{53}	PM10	36	723	0,004	0,5	
			Пыль			0,0047	0,5	
			Диоксид азота			0,0211	0,085	
			Оксид углерода			1,3620	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0007	0,2	
			Фенол			0	0,01	
			Фтористый			0	0,02	

			водород					
			Сероводород			0,0044	0,008	
13	Точка №13 координаты N41.334836, E 69.284875 (Юнусабадский р-н,) ул. А.Темура и прилегающая территория Radisson Blu Hotel	13^{55}	PM10	36	723	0,004	0,5	
			Пыль			0,004	0,5	
			Диоксид азота			0,0059	0,085	
			Оксид углерода			1,4560	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0003	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0048	0,008	
14	Точка №14 координаты N41.334836, E 69.284875 (Юнусабадский р-н,) ул. А.Темура	14^{00}	PM10	35	723	0,0041	0,5	
			Пыль			0,0047	0,5	
			Диоксид азота			0,0954	0,085	1,2
			Оксид углерода			2,4567	5	
			Диоксид серы			0	0,5	
			Аммиак			0,001	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0056	0,008	
15	Точка №15 координаты N41.334836, E 69.284875 (Юнусабадский р-н,) ул. А.Темура и прилегающая территория	14^{05}	PM10	35	723	0,0044	0,5	
			Пыль			0,0047	0,5	
			Диоксид азота			0,0792	0,085	
			Оксид углерода			2,9430	5	
			Диоксид серы			0	0,5	
			Аммиак			0,001	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0058	0,008	
16	Точка №16 координаты N41.280825, E 69.328483 (Яшнободский р-н,) ул. М.Ашрафи	15^{10}	PM10	38	722	0,0061	0,5	
			Пыль			0,0062	0,5	
			Диоксид азота			0,0166	0,085	
			Оксид углерода			0,9941	5	
			Диоксид серы			0	0,5	
			Аммиак			0,0248	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0054	0,008	
17	Точка №17 координаты	15^{15}	PM10	38	722	0,0066	0,5	
			Пыль			0,0068	0,5	

	N41.393773, E 69.227246 (Яшнободский р-н,) ул. М.Ашрафи		Диоксид азота			0,0162	0,085	
			Оксид углерода			2,0140	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0072	0,008	
18	Точка №18 координаты N41.273782 E 69.312402 (Яшнободский р-н,) ул. М.Ашрафи	15^{20}	PM10	38	722	0,0038	0,5	
			Пыль			0,0046	0,5	
			Диоксид азота			0,0110	0,085	
			Оксид углерода			2,0141	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0071	0,008	
19	Точка №19 координаты N41.270626, E 69.302735 (Мирабадский р-н,) ул. А.Фитрат	15^{25}	PM10	36	722	0,0035	0,5	
			Пыль			0,0036	0,5	
			Диоксид азота			0,0162	0,085	
			Оксид углерода			1,6980	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0054	0,008	
20	Точка №20 координаты N41.271880, E 69.279452 (Мирабадский Р-н,) ул. А.Фитрат	15^{30}	PM10	36	722	0,003	0,5	
			Пыль			0,0033	0,5	
			Диоксид азота			0,0154	0,085	
			Оксид углерода			1,0893	5	
			Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0066	0,008	
21	Точка №21 координаты N41.272033, E 69.279162 (Мирабадский	15^{35}	PM10	35	721	0,0036	0,5	
			Пыль			0,0041	0,5	
			Диоксид азота			0,0254	0,085	
			Оксид углерода			1,5122	5	

	Р-н,) ул. А.Фитрат		Диоксид серы			0	0,5	
			Аммиак			0	0,2	
			Фенол			0	0,01	
			Фтористый водород			0	0,02	
			Сероводород			0,0076	0,008	

ПДКм.р. *- предельно-допустимая концентрация, максимально разовая.*

Результаты проведённых исследований состояния атмосферного воздуха на территории г.Ташкента, **показали превышения установленных нормативов предельно допустимой максимально-разовой концентрации (ПДКм.р.)** по следующим загрязняющим веществам:

- оксид углерода в точке наблюдения №1 в 1,4 раза,
- оксид углерода в точке наблюдения №2 в 1,2 раза.
- диоксид азота в точке наблюдения №14 в 1,2 раза.

Для снижения загрязнения атмосферного воздуха предлагается реализовать следующие мероприятия: перемещение групповых котельных из жилых зон, обеспечение качественного и своевременного технического обслуживания автомобилей, включая те, что находятся в личном пользовании. Также рекомендуется создание санитарно-защитных зон вокруг промышленных предприятий, размеры которых определяются на основе расчетов рассеивания выбросов вредных веществ в атмосферу и согласно санитарной классификации организаций [15]. Необходимо также внедрить систему регулирования выбросов в атмосферу в периоды неблагоприятных метеорологических условий.

Анализ литературных источников показал, что город Ташкент характеризуется высоким уровнем загрязнения атмосферного воздуха и значительной концентрацией выбросов на каждого жителя ежегодно, что делает данную проблему особенно актуальной [16,17].

В результате проведенных вычислений было подтверждено, что концентрация загрязняющих веществ в атмосферном воздухе превышает установленные среднесуточные предельно допустимые значения в течение значительного времени по многим веществам.

Основными направлениями деятельности в области защиты атмосферы от выбросов автотранспорта включают:

- расширение производства автомобилей, оснащенных высокоэффективными и малотоксичными двигателями, включая дальнейшую дизелизацию автопарка, а также переход на альтернативные источники энергии;
- разработка и внедрение эффективных систем нейтрализации отработанных газов, в том числе и введение антидымных присадок [18];
- снижение токсичности моторных топлив;
- улучшение организации дорожного движения в городах и совершенствование инфраструктуры дорог с целью обеспечения бесперебойного движения на автомагистралях.

References:

1. Ivashhenceva, A. Jy. (2017). *Problemy zagrjaznenija atmosfernogo vozduha v gorode Omske*. Bezopasnost` gorodskoj sredy : materialy IV Mezhdunarodnoj nauchno-prakticheskoj konferencii, Omsk, 16-18 nojabrja 2016 goda. (pp.57-59). Omsk: Omskij gosudarstvennyj tehnicheskij universitet.
2. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2022). *Transport, jekologija i zdorov`e: monogr.* (p.269). Tashkent.
3. Davydova, I.S., & Gaponenko, A.V. (2017). Problema zagrjaznenija atmosfernogo vozduha v gorodah. *Sciences of Europe*. 2017. №14-2 (14). Retrieved 22.12.2023 from https://cyberleninka.ru/article/n/problema-zagryazneniya-atmosfernogo-vozduha-v-gorodah
4. Vologzhina, S.Zh., Hanaev, V.H., & Bykov, D.V. (2012). Zagrjaznenie atmosfernogo vozduha g. Shelehova. *Izvestija Irkutskogo gosudarstvennogo universiteta*. Serija: Nauki o Zemle. 2012. №. Retrieved 22.12.2023 from https://cyberleninka.ru/article/n/zagryaznenie-atmosfernogo-vozduha-g-shelehova
5. Shadimetov, Yu. Sh., & Ayrapetov, D. A. (2023). Environmental policy: experience of the European Union. *ISJ Theoretical & Applied Science*, 05 (121), 118-121.

6. Baryshnikov, I. I., & Musij-chuk, Jy. I. (1992). *Zdorov`e cheloveka / Mediko-geograficheskie aspekty ocenki urovnja zdorov`ja naselenija i sostojanija okruzhaushhej sredy*. (pp.11-36). SPb..
7. Kargapolov, N.V., & Rafailova, A.L. (2018). *Dinamika zagrjaznenija atmosfernogo vozduha u peresechenija Moskovskoj kol`cevoj avtomobil`noj dorogi (MKAD) i Kashirskogo shosse*. Komp`uternye, prikladnye i inzhenernye innovacii i modernizacija otraslej promyshlennosti: sbornik nauchnyh trudov po materialam I Mezhdunarodnoj nauchno-prakticheskoj konferencii, 20 sentjabrja 2018 g., (pp.19-22). Sankt-Peterburg: Professional`naja nauka.
8. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2022). Povyshenie jekologicheskoj bezopasnosti transportnyh potokov (na primere goroda Tashkenta). *Evrazijskij Souz Uchenyh. Serija: mezhdisciplinarnye nauki*. #7(100), pp. 4-8.
9. (2018). *Zagrjaznenie atmosfernogo vozduha avtomobil`nym transportom* / G. T. Dzhumalieva, L. Jy. Timovkina, A. A. Romanova [i dr.]. Geograficheskie nauki i obrazovanie: Materialy XI Vserossijskoj nauchno-prakticheskoj konferencii, Astrahan`, 23 marta 2018 goda / Sostavitel` V.V. Zanozin, (pp.144-147). Astrahan`: Federal`noe gosudarstvennoe budzhetnoe obrazovatel`noe uchrezhdenie vysshego professional`nogo obrazovanija "Astrahanskij gosudarstvennyj universitet", EDN UWPQHO.
10. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2022). Jekologicheskaja bezopasnost` mezhdunarodnyh transportnyh koridorov. *Naukosfera*. №11 (1), pp.84-89.
11. Kargapolov, N.V. (2010). *Geohimicheskaja jekologicheskaja funkcija atmosfery gorodov. Geografija: problemy nauki i obrazovanija: LXIII Gercenovskie chtenija.* Materialy ezhegodnoj Mezhdunarodnoj nauchnoprakticheskoj konferencii 22-24 aprelja 2010 g., (pp.30-32). Sankt-Peterburg.
12. Kargapolov, N. V. (2019). Tehnologija ocenki zagrjaznenija atmosfernogo vozduha avtomobil`nym transportom. *Evrazijskoe Nauchnoe Ob#edinenie*, 2019, № 10-4(56), pp. 351-356, EDN RCAYTS.
13. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2023). *«Zelenaja» jenergetika: opyt zarubezhnyh stran, problemy i perspektivy*. «Yashil» energetikani amaliyotga tatbiq etish: yutuqlar va muammolar» mavzusida respublika ilmiy-amaliy konferensiyasi materiallari to‘plami 2023 - 247-253 V.
14. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2023). Gorodskaja pyl`: problemy i puti reshenija (na primere g. Tashkent). *Naukosfera*. №3 (2), 2023 pp.92-97.
15. Stolbun, O.A., Savlukova, O.I., & Kotljar, E.V. (2012). O zagrjaznenii atmosfernogo vozduha v Ussurijske. *Zdorov`e. Medicinskaja jekologija. Nauka.* 2012. №3-4. https://cyberleninka.ru/article/n/o-zagryaznenii-atmosfernogo-vozduha-v-ussuriyske
16. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2023). Vlijanie promyshlennosti na okruzhaushhuu sredu i zdorov`e naselenija. *Naukosfera*. №4 (2), 2023, pp.76-81.
17. Shadimetov, Jy.Sh., & Ajrapetov, D.A. (2023). *Aktual`nye problemy ohrany atmosfernogo vozduha.* “Atrof-muhit muhofazasi va ekologik rayonlashtirish: muammo va yechimlar” mavzuida xalqaro ilmiy-amaliy anjuman 2023 - 258-266 V.
18. Barhanadzhjan, A.L. Hakimov, R.M., Zhumanijazova, R.H., Abdukarimova, G.O., & Ajrapetov, D.A. (2019). *Snizhenie toksichnosti otrabotavshih gazov dizel`nyh avtomobilej*. Sbornik materialov mezhdunarodnoj nauchno-tehnicheskoj konferencii 21-23 nojabrja 2019, pp.60-63.

Impact Factor:					
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2024 **Issue:** 02 **Volume:** 130
Published: 05.02.2024 **http://T-Science.org**

Issue Article

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ISOLATION OF CARBONATE RESERVOIRS AND ASSESSMENT OF THEIR CAPACITIVE PROPERTIES BY ACOUSTIC AND NEURAL GAMMA LOGGING

Abstract: *the article summarizes the results of experimental and methodological work carried out over a number of years of geophysical research, describes methods for determining porosity by acoustic, neural gamma logging; extreme values of gamma and neutron gamma logging, as well as methods for isolating and evaluating reservoirs of complex structure. These techniques and methods of interpretation are intended for the study of carbonate deposits of the Jurassic and Cretaceous deposits of Turkmenistan and are recommended for testing in all geophysical organizations conducting research on complex carbonate reservoirs.*

Prospecting and exploration for oil and gas in Turkmenistan is mainly associated with Mesozoic sediments lying at depths up to 5000 m or more, represented by both terrigenous and carbonate rocks. These deposits are exposed in difficult geological and technical conditions; the reservoir is predominantly of complex structure, which makes it difficult to isolate them due to the poor knowledge of geophysical dependencies and petrophysical security of geophysical dependencies.

Key words: *mineral, porosity, core, reservoir, clay crust, parameter, diagram, logging, wave, formation.*
Language: *English*
Citation: Deryaev, A. R. (2024). Isolation of carbonate reservoirs and assessment of their capacitive properties by acoustic and neural gamma logging. *ISJ Theoretical & Applied Science, 02 (130),* 10-16.
Soi: http://s-o-i.org/1.1/TAS-02-130-2 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.02.130.2
Scopus ASCC: *2209.*

Introduction

On the territory of Turkmenistan, carbonate deposits have a widespread distribution and stratigraphically belong to the Upper Jurassic and Lower Cretaceous ages. A large range of depth variations, clay content varying in section and area, complex tectonic and thermobaric conditions, and heterogeneous mineral composition led to the development of reservoirs of various types: pore, pore-fractured, pore-cavernous or pore-fractured-cavernous with a predominance of one or another type of porosity, which are established by geophysical data [1, 2].

Analysis of the geophysical characteristics of the tested objects showed that in most cases these are reservoirs with a predominance of intergranular porosity exceeding 5-6% and only in some cases the porosity coefficient is 3.5-5% (Fig.1).

The established boundary values of the geophysical parameters ΔJny and $\Delta J\gamma$ (double difference parameters of neutron-gamma logging (NGL) and gamma logging (GL), respectively) are 0.75 and 0.35.A comparison of the core analysis data (K_p, K_{per}) also indicates the validity of the above data (Fig. 2) [3, 4, 5].

In the carbonate deposits of the Central and Western part of Turkmenistan, reservoirs are mainly represented by low-power boards (1-3 m). The proportion of reservoirs with a capacity of 4 m or more is an insignificant part, therefore, lateral electrical sounding is extremely rarely used to isolate reservoirs [6].

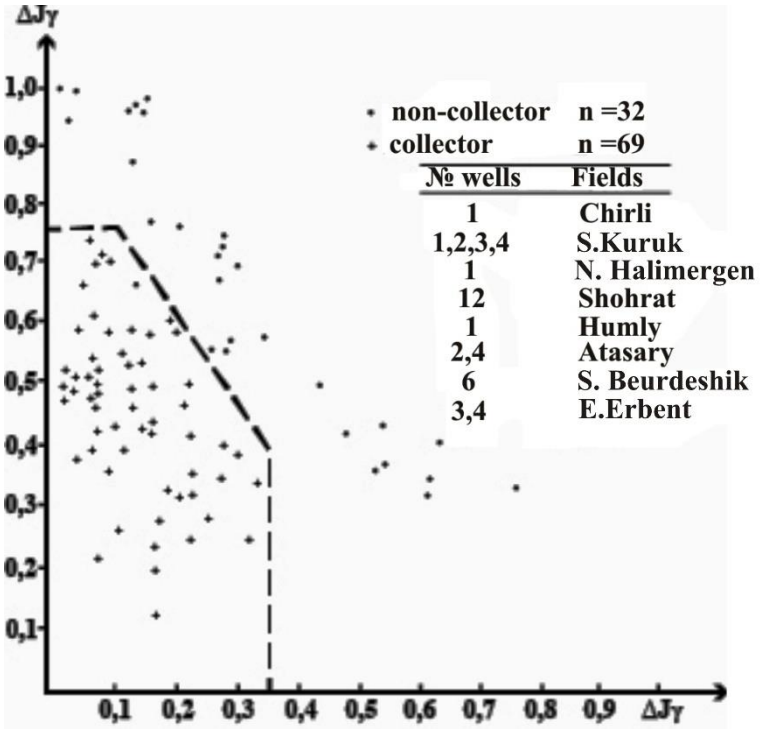

Fig.1. Determination of the boundary ΔJny and ΔJy for the separation of carbonate rocks of the Mesozoic of the Central part of Turkmenistan into reservoirs and non-reservoirs according to tested objects.

The main signs of pore-type reservoirs are the presence of negative PS (spontaneous polarization) anomalies, low values and increments of AR (apparent resistivity) in microcarotage diagrams, a decrease in the diameter of the well due to the formation of a clay crust [7-10].

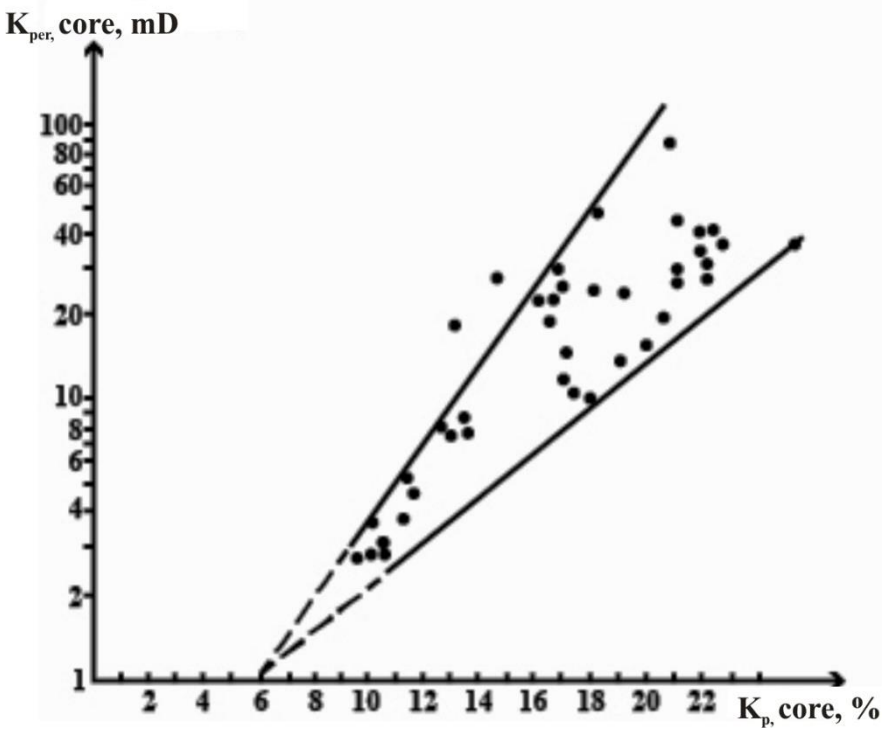

Fig. 2. Comparison of the open porosity of the K_p and the permeability of the K_{per} of carbonate rocks of the productive horizons of the Beurdeshik field

However, with a decrease in reservoir capacity, the efficiency of reservoir allocation according to the listed criteria also decreases. In these cases, as well as to isolate collectors of complex structure, temporary measurements of electrical logging, simultaneous studies with devices having different radial characteristics (MLL-LL), and mechanical logging data are used [11, 12].

Determination of porosity by acoustic logging. The average time equation has become the most widespread in the practice of field and geophysical research to determine porosity

$$K^{AL}{}_P = \frac{\Delta T = \Delta T_{sk}}{\Delta_{liq.} = \Delta T_{sk}} \qquad (1)$$

Its application presupposes knowledge of three values; the interval time of the longitudinal wave in the studied formation - ΔT, the time in the mineral skeleton of the rock - ΔT_{sk} and in the liquid filling the rock vapor in the research area AL - ΔT_{liq}. However, it should be borne in mind that the above equation is not a functional, but an approximate empirical dependence $V_p=f(K_p)$, and the closest to the actual values of porosity are obtained with the correct choice of the initial values ΔT_{sk} and ΔT_{liq}.

For pure monomineral rocks, the values of ΔT_{sk} are well maintained for various oil and gas bearing regions of the globe. For the studied deposits of the Lower Cretaceous and Jurassic (dolomites, limestones, anhydrides, sandstones), a comparison of $\rho^{LL}{}_4$ and ΔT was performed. The values of ΔT, which practically correspond to the layers of dolomites, limestones, anhydrides, sandstones with zero porosity, are respectively 142 mcs/m, 155, 164, 172 mcs/m. It is recommended to use these values as ΔT_{sk} [13, 14, 15].

In the vast majority of cases, the radius of the acoustic logging probe is located within the penetration zone, where the pores of the rock are filled with a mixture of filtrate and reservoir fluid. The interval time depends on the mineralization of the mixture, pressure and temperature and can be calculated from the following ratios:

$$T_{liq.} = [1410 + 1{,}21t = 0{,}037(t)^2 + 1{,}148 + 0{,}18P_к]I_x 10^6 \quad (2)$$

or

$$T_{liq.} = [1557 - 0{,}0245(75 - t)2 + 0{,}80C_{liq.} + 0{,}19P_{liq.}]I_x 10^6 \quad (3)$$

where t - temperature of the mixture, °C; S - salinity of the mixture, %; $R_{liq.}$ - hydrostatic pressure, kg/cm^2; $C_{liq.}$ - mineralization of the mixture, g/l.

In 1975, based on laboratory data, the dependences of $\Delta T_{liq.}$ on pressure and temperature for fixed values of $C_{liq.}$ were constructed.

In 1979, according to formula (2), a complex pallet was calculated and constructed to determine $\Delta T_{liq.}$ at a temperature change of up to 240 °C and a pressure of 650 kg/cm^2. The values of $\Delta T_{liq.}$ determined by various methods for the geological and technical conditions of the studied deposits vary within the range of 590-610 mcs/m.

For practical purposes, when determining the K_p, it is recommended to use $\Delta T_{liq} = 600$ mcs/m, while the absolute error when changing the K_p from 2% to 9% increases from 0.05% to 0.2%; when changing the K_p from 9% to 22.5% - from 0.2% to 0.5%. In all cases, the relative error does not exceed 5%.

Determination of porosity by neutron gamma logging. In Turkmenistan, the technique of two support layers using a relative parameter has found the greatest application in determining porosity coefficients from neutron gamma γ-logging.

$$\Delta J_{n\gamma} = \frac{J_{n\gamma}\text{lay.} - J_{n\gamma}min}{J_{n\gamma}max - J_{n\gamma}min} \qquad (4)$$

where $J_{n\gamma\ lay.}$, $J_{n\gamma\ \min}$, $J_{n\gamma\ \max}$ - NGL readings in the studied and support layers, respectively.

Knowing the value of the relative parameter $\Delta J_{n\gamma}$ according to the dependence $\Delta J_{n\gamma} = f(K_p)$, it is defined as $K^{AL}{}_P$ (Fig.3).

The support layers must comply with the following instructions. A limestone or dolomite formation with maximum NGL readings should be sufficiently powerful ($h \geq 3$ m), non-clay, the porosity of which is assumed to be 1-3%. The specified range of changes in the porosity of the support layer introduces a significant error in determining the $K^{NGL}{}_P$, since in this case the range of changes in $J_{n\gamma}$ can reach one conventional unit. It should also be borne in mind that the studied carbonate deposits lie at considerable depths (3000-4500 m or more). The specific electrical resistances of formations with maximum NGL readings reach 1000 and more than 0mm, therefore, their porosity coefficients are significantly lower than 1%.

Clay layers, where the diameter of the well is eroded to 50 cm or more, should be used as support layers with minimal NGL readings [16, 17, 18]. The porosity of such layers is considered to be equivalent to 35-48%. There are practically no formations with such parameters in the studied sections. It is not uncommon for there to be no support layers at all in the intervals of the NGL study that meet the above requirements.

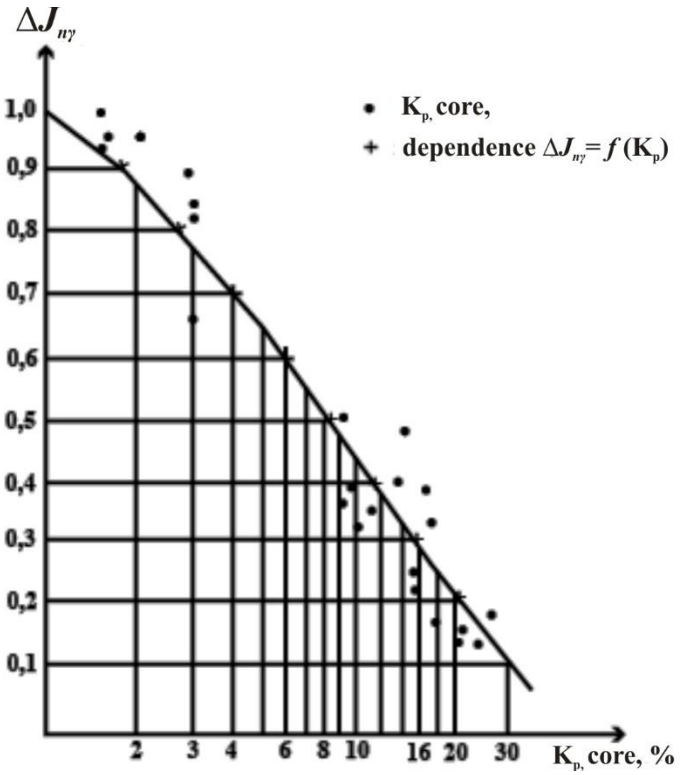

Fig. 3. Dependence of the relative parameter $\Delta J_{n\gamma}$ on the core porosity $K_{p.core}$

To increase the reliability of the results of quantitative interpretation of NGL materials, the following method is proposed for determining the extreme values of the support layers [19, 20]. The values or $P_{пи}$ of NGC for the studied formations are compared in a semi-logarithmic coordinate system (Fig. 4). For formations with granular porosity, numerous studies have established a relationship close to linear in such a coordinate system.

An averaging dependence line is drawn along the points characterizing non-clay formations with granular porosity, moreover, the position of the point for a formation with K_p = 48% is determined by the coordinates P_p=5+10 and 1 conventional unit in the NGL diagram [21]. The correctness of the choice of this point is confirmed by the results of determining the values of the pairs *Jnγ* and ω cl. ($Kp^{proc.}$) in clay layers in the range 2308-2320m, 2254-2260m, 2287-2290m, 20184-2020m (well.2-Dengli), which are characterized by the following parameters:

1. d c = 26 cm *Jnγ* = 1,80 conv. un. ω cl = 22 Pp = 38
2. d c = 26 cm *Jnγ* = 1,66 conv. un. ω cl = 26 Pp = 26
3. d c = 29 cm *Jnγ* = 1,60 conv. un. ω cl = 27 Pp = 23
4. d c = 43 cm *Jnγ* = 1,40 conv. un. ω cl = 37 Pp = 10

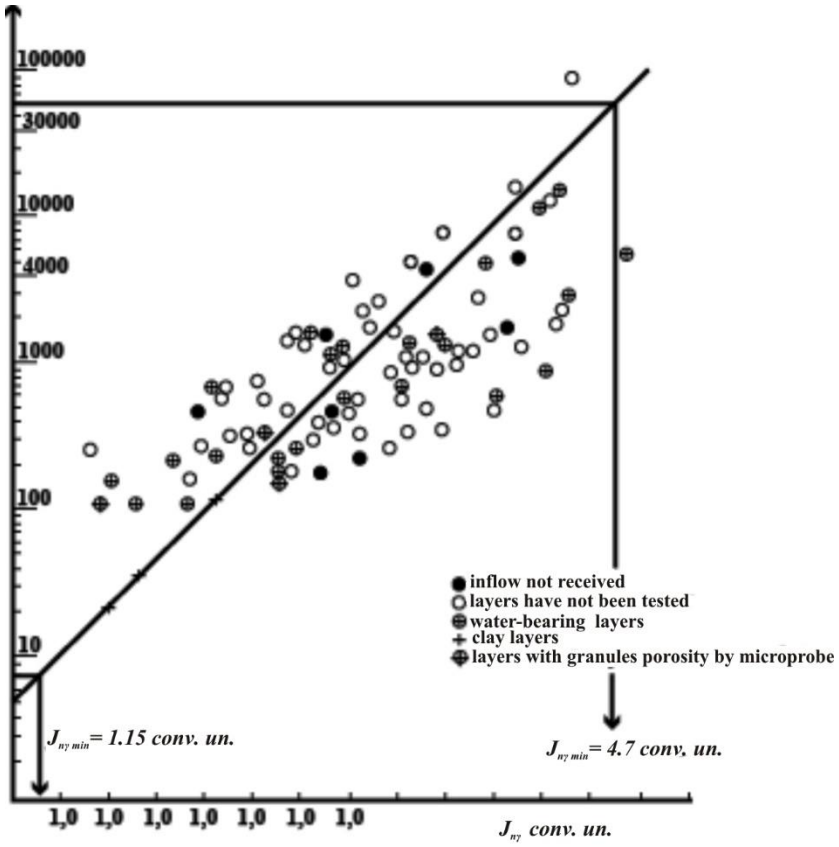

Fig. 4. Determination of the extreme values of NGL (well 2, Dengli square)

These strata, stratigraphically dated to the Aptian-Albian age, are regionally traced in the studied areas, and can be used for monitoring when conducting a line of granular rocks [22, 23]. In addition, limestone and dolomite layers with granular porosity, highlighted in microprobe diagrams, are used for this purpose.

We find the extreme values of NGL. To determine the position of a formation with a porosity of 1%, it is necessary to continue the line of granular rocks to the intersection with the ordinate – $P_{p.d.}$ = 60000 (K_p = 1%). Thus, we obtain the value of $J_{nγ\,max}$ = 4.70 cont.units. The minimum value of $J_{nγ\,min}$, corresponding to $\omega_{cl.}$ = 40%, will be characterized by a relative resistance equal to 7.5, which through the dependence $P_p = f(J_{nγ})$ they are transferred to the abscissa axis (Fig. 4).

It will correspond to 1.15 conventional units on the scale of the diagram. Porosity is determined by the value of the relative parameter ΔJny according to the dependence $\Delta J_{nγ} = f(K_p)$ or by the porosity scale plotted directly on the diagram according to the known extreme values of NGL [24, 25].

The choice of extreme values of NGL according to the above methodology will provide a unified approach to the selection of support layers, eliminate subjectivity, which will lead to an increase in the reliability of the results of quantitative interpretation of materials.

References:

1. Deryaev, A.R. (2022). Zadachi issledovaniya dlya metoda odnovremennoj razdel'noj ekspluatacii mnogoplastovyh mestorozhdenij. *Innovacionnye nauchnye issledovaniya* №2-2 (16) – Ufa: Nauchno-izdatel'skij centr "Vestnik nauki", pp. 43–51.
2. Deryaev, A.R. (2022). *Vskrytie produktivnyh gorizontov burovym rastvorom na uglevodorodnoj osnove dlya odnovremenno-*

razdel'noj ekspluatacii. Sbornik statej Mezhdunarodnoj nauchno-prakticheskoj konferencii "Nauka v sovremennom obshchestve: zakonomernosti i tendencii razvitiya". (pp.35-39). Ufa: Izdatel'stvo OOO "Omega sajns".

3. (1979). *Metodicheskie rekomendacii po provedeniyu issledovanij i interpretacii dannyh nejtronnogo karotazha s serijnoj apparaturoj RK*. M.: VNIIYAGG.
4. (1982). *Interpretaciya rezul'tatov geofizicheskih issledovanij razrezov skvazhin*. M.: Nedra.
5. Latyshova, M. G. (1981). *Prakticheskoe rukovodstvo po interpretacii diagramm geofizicheskih metodov issledovaniya skvazhin*. - M.: Nedra.
6. Deryaev, A.R. (2022). *Sovremennoe sostoyanie izuchennosti bureniya napravlennyh i mnogozabojnyh skvazhin s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov (zarubezhnyj opyt)*. Sbornik statej mezhdunarodnogo nauchno-issledovatel'skogo konkursa "Akademicheskaya nauka na sluzhbe obshchestvu". (pp.170-178). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
7. (1972). *Metodicheskie rekomendacii po kolichestvennoj interpretacii dannyh karotazha*. - M.: VNIIGeofizika.
8. Basin, Ya.N., Kuharenko, N.K., & Tyukaev, Yu. V. (1968). *Metodika opredeleniya poristosti karbonatnyh plastov po dannym nejtronnogo karotazha s serijnoj apparaturoj radioaktivnogo karotazha*. – M.: VNIIYAGG.
9. Deryaev, A.R. (2022). Rekomendacii po kompleksnomu vnedreniyu s razdel'noj ekspluataciej odnovremenno neskol'kih gorizontov na gazovyh mestorozhdeniyah Turkmenistana. *Problemy nauki* №1 (69) – M: Izdatel'stvo "Problemy nauki", pp.16-21.
10. Deryaev, A.R. (2022). Ohrana nedr i okruzhayushchej sredy pri razrabotke gazovyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii. *Nauchnyj zhurnal Metod Z* №2 (4) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.12-14.
11. Deryaev, A.R., & Orazklychev, K. (2015). *Sposob odnovremenno-razdel'noj dobychi nefti i gaza iz mnogoplastovoj zalezhi odnoj skvazhinoj*. Patent № 644 ot 08.06.2015. (nomer zayavki 15/101320).
12. Deryaev, A.R., & Orazklychev, K. (2015) *Sposob odnovremenno-razdel'noj i sovmestnoj ekspluatacii neskol'kih produktivnyh gorizontov odnoj skvazhinoj i ustrojstvo dlya ego osushchestvleniya*. Patent № 643 ot 08.06.2015. (nomer zayavki 14/101317).
13. Semenov, V.N. (2010). Opyt razrabotki i osvoeniya tekhnologii ORRNEO mekhanizirovannym sposobom. V.N.Semenov. *Inzhenernaya praktika*. №1, pp. 85-89.
14. Osipov, M. G. (1957). Dobycha bezvodnoj nefti iz zalezhi s podoshvennoj vodoj. *Neftyanoe hozyajstvo*. №12, pp. 42-51.
15. Parijchuk, N.I. (2011). Opyt vnedreniya tekhnologij OOO «SP-BARS» dlya sovmestnoj razrabotki neskol'kih gorizontov v neftedobyvayushchih kompaniyah Rossii N.I. Parijchuk *Inzhenernaya praktika*. №3, pp. 69-71.
16. 16 Deryaev, A.R. (2022. *Osobennosti bureniya naklonno-napravlennyh skvazhin i tekhnologiya ih odnovremennoj razdel'noj ekspluatacii.* "Fundamental'naya i prikladnaya nauka: sostoyanie i tendencii razvitiya". Monografiya. (pp.76-96). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
17. Belen'kij, V.I. (1964). Razrabotka neftyanyh mestorozhdenij s primeneniem metoda odnovremennoj razdel'noj ekspluatacii dvuh plastov v odnoj skvazhine. Opyt odnovremennoj razdel'noj ekspluatacii neskol'kih plastov cherez odnu skvazhinu., Ser. *Dobycha: nauch.-analit. i temat. obzory*. (pp.31-43). M.: CNIITEneftegaz CNIITEneftegaz.
18. Diyashev, R.N., Musabirova, N.H., & Iktisanova, V.A. (1997). *Metodicheskoe rukovodstvo po opredeleniyu optimal'nyh plastovyh i zabojnyh davlenij*. (p.88). Bugul'ma: TatNIPIneft'.
19. Deryaev, A.R. (2022). Treatment of drilling mud with "PACS-T" additive. *"Innovative approaches in the modern science"* Proceedings of CXV international scientific – practical conference. International scientific journal №7 (115) – M:. pp. 74–77.
20. Deryaev, A.R. (2022). *Rekomendacii po burovomu rastvoru dlya bureniya sekcii 295,3 mm otkrytogo stvola naklonno-napravlennoj skvazhiny*. Sbornik statej II Mezhdunarodnoj nauchno-prakticheskoj konferencii "Nauka, obshchestvo, tekhnologii: problemy i perspektivy vzaimodejstviya v sovremennom mire". (pp.7-11). Petrozavodsk: Nauchnoe izdanie: MCNP "Novaya nauka".
21. (1974). *Spravochnaya kniga po dobyche nefti.*, pod.red.SH.K. Gimatudinova. (p.704). M.: Nedra.
22. Deryaev, A.R. (2022). Provedenie promyslovyh ispytanij kompleksnoj ingibirovannoj dobavki KAIR-T na neftegazovyh ploshchadyah Turkmenistana. *Problemy sovremennoj nauki i obrazovaniya №1(170)* – M: Izdatel'stvo "Problemy nauki", pp.11-17.
23. Deryaev, A.R. (2022). Osnovnye perspektivy razvitiya i inzhenernoe planirovanie burovyh rabot dlya rezul'tativnosti gorizontal'nogo bureniya. *Nauka, tekhnika i obrazovanie* №1 (84) – M: Izdatel'stvo "Problemy nauki", pp.33-38.

24. Deryaev, A.R. (2022). Metody opredeleniya tekhnologicheskih pokazatelej effektivnosti odnovremennoj razdel'noj ekspluatacii. Nauchnyj zhurnal *Metod Z* №1(3) – Sankt-Peterburg: Izdatel'stvo: GNII «Nacrazvitie», pp.8-10.
25. Geldimyradov, A. G., & Deryaev, A.R. (2022). *Razrabotka gazokondensatnyh mestorozhdenij metodom odnovremennoj razdel'noj ekspluatacii*. «Instrumenty i mekhanizmy ustojchivogo innovacionnogo razvitiya» Monografiya vypusk №67 – Ufa: Nauchnoe izdanie: NIC “Aeterna”, pp. 22-37.

Impact Factor:					
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2024 **Issue:** 02 **Volume:** 130
Published: 05.02.2024 **http://T-Science.org**

Issue Article

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ASPECTS OF TEACHING MATHEMATICAL MODELING

Abstract: *This paper describes some particular aspects associated with teaching of mathematical modeling. Taking into account these aspects allows improving the quality of graduates training and increasing their competitiveness.*

Key words: *education, mathematical model, mathematical modeling, principled approach, teaching.*
Language: *Russian*
Citation: Markelov, G. E. (2024). Aspects of teaching mathematical modeling. *ISJ Theoretical & Applied Science, 02 (130),* 17-25.
Soi: http://s-o-i.org/1.1/TAS-02-130-3 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.02.130.3
Scopus ASCC: *3304.*

ОСОБЕННОСТИ ПРЕПОДАВАНИЯ МАТЕМАТИЧЕСКОГО МОДЕЛИРОВАНИЯ

Аннотация: *В статье изложены некоторые особенности, связанные с преподаванием математического моделирования. Учет таких особенностей позволяет улучшить качество подготовки выпускников, повысить их конкурентоспособность.*

Ключевые слова: *образование, математическая модель, математическое моделирование, принципиальный подход, обучение.*

Введение

Математическое моделирование как способ исследования и получения новых знаний применяют в различных областях человеческой деятельности. Многие научные публикации показывают возможности, которые открывает математическое моделирование. В настоящее время возрастает роль междисциплинарных исследований, формируются новые научные направления, успешно использующие междисциплинарный подход. В связи с этим заслуживают внимания работы (см., например, [1–5]), которые демонстрируют возможности математического моделирования при решении профессиональных задач, возникающих на стыке нескольких академических дисциплин.

Возникновение новых фундаментальных и прикладных задач приводит к необходимости дальнейшего активного использования математического моделирования. Это обусловлено многими причинами, среди которых: усложнение и сокращение сроков исследований, рост финансовых, энергетических и других затрат на обслуживание экспериментов, необходимость решения экологических, социальных и других сопутствующих исследованию проблем.

Математическое моделирование активно используют в современной системе образования. Проблемы, связанные с преподаванием элементов математического моделирования, широко обсуждаются в современной научной литературе, при этом рассматриваются разные точки зрения (см., например, [6–11]). Многие ученые считают, что изучение математического моделирования повышает математическую грамотность обучающихся, развивает их познавательные способности, создает лучшую мотивацию учения, укрепляет междисциплинарные связи (см., например, [12–15]).

В этой связи становится важным преподавание математического моделирования, направленное на изучение современных методов построения математических моделей, способов качественного и количественного анализа математических моделей, методик, позволяющих рационально использовать возможности математического моделирования.

Целью настоящей работы является изложение некоторых теоретических и методологических особенностей преподавания математического моделирования, которые создают предпосылки для рационального использования возможностей математического моделирования. В рамках данной работы в соответствии с выбранной целью уточнен существующий понятийный аппарат, обозначены этапы математического моделирования, которые могут быть реализованы обучающимися, предложена типовая задача, решение которой формирует необходимые навыки, даны методологические рекомендации по организации учебного процесса.

1. Понятия и определения

Подходы к построению математической модели, способы и методы ее изучения подробно изложены в обширной учебной и научной литературе (см., например, [16–19]). Однако в некоторых случаях возможности математического моделирования используют не рационально. Одна из причин этого заключается в том, что построенные математические модели не обладают нужными свойствами.

Основываясь на передовом педагогическом опыте, уточним понятие «математическое моделирование», которое определим как замену объекта исследования пригодной математической моделью и ее последующее изучение известными методами, способами. Математическую модель считаем пригодной, если она в достаточной мере обладает нужными свойствами применительно к конкретному исследованию.

1.1. Свойства математических моделей

Математическая модель может обладать многими свойствами. Однако ее использование не будет эффективным, если среди этих свойств отсутствуют те, которые нужны для проводимого исследования. Далее приведем краткое описание некоторых свойств математических моделей [20].

Свойство полноты. Полная математическая модель отражает существенные в данном случае свойства и качества объекта исследования.

Свойство адекватности. Адекватная математическая модель обеспечивает правильное качественное и точное количественное описание представляющих интерес характеристик объекта исследования. Например, при изучении технических устройств или систем математическую модель считают адекватной, если она описывает представляющие интерес количественные характеристики объекта исследования с относительной погрешностью не более заданного значения δ_0.

Свойство продуктивности. Это свойство связывают с возможностью располагать достоверными исходными данными. Если такой возможности нет, то математическая модель не обладает свойством продуктивности, ее дальнейшее использование становится затруднительным или невозможным.

Свойство экономичности. Если математическая модель обладает свойством экономичности, то ее изучение не требует больших затрат времени и ресурсов. Чем более простой является математическая модель, тем в большей степени она обладает этим свойством.

Установив нужные для проводимого исследования свойства, можно сформулировать требования к математической модели объекта исследования. Такие требования противоречивы и на практике могут быть удовлетворены на основе разумного компромисса, достигаемого при прохождении этапов математического моделирования.

1.2. Основные этапы математического моделирования

На рис. 1 представлена схема, которая определяет последовательность проведения основных этапов математического моделирования. В общем случае можно выделить следующие этапы математического моделирования.

На первом этапе математического моделирования выполняют неформальный переход от объекта исследования к его содержательной модели. Под содержательной моделью понимают условное описание объекта исследования, которое должно учитывать его особенности и количественные характеристики, существенные для рассматриваемого случая. При этом обосновывают допущения и упрощения, позволяющие не учитывать те свойства и качества объекта исследования, которые предполагают несущественными.

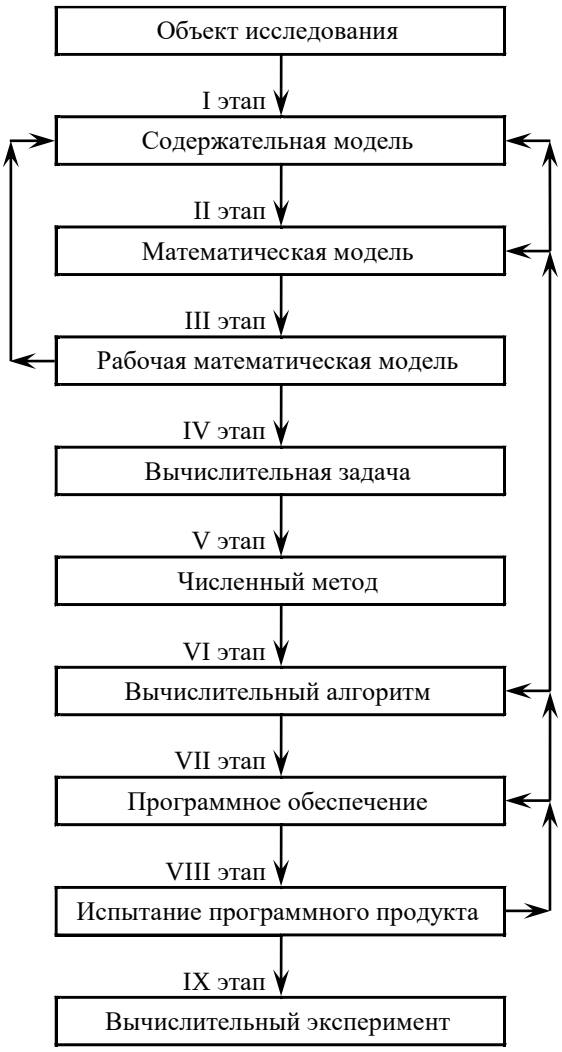

Рисунок 1 – Этапы математического моделирования.

На втором этапе осуществляют математическое описание содержательной модели. В результате такого формального описания получают математическую модель объекта исследования, причем можно разработать не одну, а несколько математических моделей одного и того же объекта исследования.

На третьем этапе математического моделирования при выполнении качественного и оценочного количественного анализа математической модели могут возникнуть основания для уточнения или пересмотра содержательной модели, что приведет к повторному прохождению первого этапа математического моделирования. Сравнение результатов анализа различных математических моделей позволяет сделать обоснованный выбор математической модели для дальнейшего детального количественного анализа. Итогом рассматриваемого этапа является разработка рабочей математической модели, то есть математической модели, предназначенной для детального количественного анализа.

На четвертом этапе формулируют вычислительную задачу, анализ результатов решения которой может дать ответы на интересующие вопросы.

На пятом этапе математического моделирования осуществляют обоснованный выбор или построение численного метода. Как правило, численный метод не включает многие детали, без которых невозможно использовать средства вычислительной техники. Тут необходима подробная детализация всех этапов вычислений, для того чтобы получить реализуемый алгоритм вычислительного эксперимента. Разработка эффективного алгоритма вычислительного эксперимента является итогом шестого этапа математического моделирования.

На седьмом этапе разрабатывают программное обеспечение, реализующее вычислительный алгоритм.

На восьмом этапе проводят испытание программного продукта. Тщательная проверка результатов расчетов может обнаружить недостатки, для устранения которых необходимо прохождение предыдущих этапов математического моделирования. После устранения всех выявленных недостатков приступают к реализации вычислительного эксперимента. Проведение вычислительного эксперимента является итогом завершающего девятого этапа математического моделирования.

Представленная последовательность этапов математического моделирования может видоизменяться в конкретных случаях. При этом для удовлетворения противоречивых требований, предъявляемых к математической модели объекта исследования, обычно соблюдают правила и выполняют рекомендации, которые стали результатом обобщения практического опыта, накопленного при построении математических моделей. В этой связи особый интерес представляют принципы построения математических моделей, которые носят общий и универсальный характер. Далее рассмотрим наглядный пример построения пригодной математической модели.

2. Пример построения математической модели

Построим пригодную математическую модель объекта исследования, используя широко известный принцип — принцип постепенного усложнения. Согласно данному принципу построение математической модели объекта исследования необходимо начинать с простейших математических моделей. Если модель обладает нужными свойствами применительно к конкретному исследованию, то ее используют на последующих этапах математического моделирования. В противном случае необходимо осуществить следующий цикл модификации математической модели, который приведет к построению более сложной модели, проверке ее пригодности и так далее до тех пор, пока не будет получена пригодная математическая модель. В этом случае удается построить целую совокупность моделей одного и того же объекта исследования. Сравнение результатов, полученных с использованием различных математических моделей, может не только обогатить познание о рассматриваемом объекте исследования, но и повысить достоверность полученных результатов.

2.1. Постановка задачи

Рассмотрим параллельное соединение терморезисторов. Пусть T_i — температура i-го терморезистора, которая не зависит от пространственных координат, причем $T_i \le T^*$, $i \le n$. Температура T_i в начальный момент времени t_0 равна T_0. На поверхности терморезистора площадью S_i происходит конвективный теплообмен с окружающей средой, температура которой равна T_0, коэффициент теплоотдачи известен и равен α_i. Для сравнительно узкого диапазона температур от T_0 до T^* считаем, что

$$R_i(T_i) = r_i\left[1+\beta_i(T_i - T_0)\right],$$

$$C_i(T_i) = c_i\left[1+\gamma_i(T_i - T_0)\right],$$

где $R_i(T_i)$ и $C_i(T_i)$ — сопротивление и полная теплоемкость i-го терморезистора; r_i и c_i — сопротивление и полная теплоемкость i-го терморезистора при $T_i = T_0$; β_i и γ_i — положительные постоянные величины. Через i-й терморезистор протекает электрический ток, сила которого равна

$$I_i = \frac{U}{r_i\left[1+\beta_i(T_i - T_0)\right]}, \qquad (1)$$

где U — постоянная разность электрических потенциалов на полюсах i-го элемента.

Пусть в рамках проводимого исследования представляет интерес величина

$$I = \sum_{i=1}^{n} I_i. \qquad (2)$$

Построим математическую модель макроуровня объекта исследования, которая в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

2.2. Решение задачи при $n = 1$

Для решения поставленной задачи разделим объект исследования на отдельные более простые элементы, допускающие их независимое исследование с последующим учетом взаимного влияния. Это позволяет перейти к рассмотрению технической системы, которая включает только один терморезистор, т. е. $n = 1$.

Выстроим иерархию математических моделей макроуровня такой технической системы и определим условия, при выполнении которых можно с относительной погрешностью не более заданного значения δ_0 найти искомую величину I_1.

Если разность $T_1 - T_0$ достаточно мала, то согласно (1) найдем искомую величину по формуле

$$I_0 = \frac{U}{r_1}. \qquad (3)$$

Определим условия, при которых применима полученная формула. Для этого рассмотрим установившийся процесс теплообмена. В этом случае мощность тепловыделения в материале терморезистора равна тепловому потоку, отводимому от терморезистора, т. е.

$$\frac{U^2}{R_1(T_*)} = \alpha_1(T_* - T_0)S_1,$$

где T_* — установившееся значение температуры терморезистора. Из полученного равенства легко найти

$$T_* = T_0 + \frac{1}{2\beta_1}\left(-1 + \sqrt{1 + \frac{4\beta_1 U^2}{\alpha_1 S_1 r_1}}\right),$$

а затем определить установившееся значение искомой величины

$$I_* = \frac{2U}{r_1\left[1 + \sqrt{1 + 4\beta_1 U^2 \alpha_1^{-1} S_1^{-1} r_1^{-1}}\right]}, \qquad (4)$$

причем для данного диапазона температур

$$\frac{U^2}{\alpha_1 S_1 r_1 (T^* - T_0)} \le 1 + \beta_1 (T^* - T_0). \qquad (5)$$

Для относительной погрешности величины I_0 запишем

$$\delta(I_0) = \left|\frac{I_1 - I_0}{I_1}\right| = \frac{I_0}{I_1} - 1 \le \frac{I_0}{I_*} - 1.$$

При выполнении неравенства

$$\frac{I_0}{I_*} - 1 \le \delta_0$$

можно с относительной погрешностью не более δ_0 использовать формулу (3) для нахождения искомой величины. Следовательно, при выполнении неравенства

$$I_0 \le (1 + \delta_0) I_* \qquad (6)$$

математическая модель макроуровня (3) в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Затем определим условия, при которых применима математическая модель (4). Для этого рассмотрим неустановившийся процесс теплообмена. В этом случае изменение температуры терморезистора во времени t описывает обыкновенное дифференциальное уравнение первого порядка

$$C_1(T_1)\frac{dT_1}{dt} = \frac{U^2}{R_1(T_1)} - \alpha_1(T_1 - T_0)S_1,$$

а начальное условие имеет вид

$$T_1(t_0) = T_0.$$

Учитывая, что

$$I_1 = \frac{I_0}{1 + \beta_1(T_1 - T_0)},$$

сформулируем задачу Коши

$$\frac{c_1 U}{\beta_1 r_1 I_1^2}\frac{dI_1}{dt} = \frac{\alpha_1 S_1 U - \alpha_1 S_1 r_1 I_1 - \beta_1 r_1 U I_1^2}{\gamma_1 U - \gamma_1 r_1 I_1 + \beta_1 r_1 I_1},$$

$$I_1(t_0) = U r_1^{-1}. \qquad (7)$$

Тогда найдем момент времени

$$t_1 = t_0 + \frac{c_1}{\alpha_1 S_1}\left[\frac{\gamma_1}{\beta_1}\left(\frac{r_1 I_*}{U} - 1 + \delta_0\right)\frac{U}{r_1 I_*} + \right.$$

$$+\left(\frac{U}{2U - r_1 I_*} + \frac{\gamma_1}{\beta_1}\frac{U - r_1 I_*}{2U - r_1 I_*}\frac{U}{r_1 I_*} - 1\right)\times$$

$$\times \ln\left(2 - \frac{r_1 I_*}{U} - \delta_0\right) - \left(\frac{U}{2U - r_1 I_*} + \right.$$

$$\left.\left. + \frac{\gamma_1}{\beta_1}\frac{U - r_1 I_*}{2U - r_1 I_*}\frac{U}{r_1 I_*}\right)\ln\left(\frac{U}{U - r_1 I_*}\delta_0\right)\right],$$

для которого

$$I_1(t_1) = \frac{I_*}{1 - \delta_0}.$$

Очевидно, что при $t \ge t_1$

$$\delta(I_*) = \left|\frac{I_1 - I_*}{I_1}\right| = 1 - \frac{I_*}{I_1} \le \delta_0,$$

а значение I_* можно с относительной погрешностью не более δ_0 считать равным $I_1(t)$. Следовательно, можно с относительной погрешностью не более δ_0 использовать формулу (4) для нахождения искомой величины. Это позволяет сформулировать следующее утверждение об использовании математической модели (4).

Утверждение 1. Если не выполнено условие (6), то математическая модель макроуровня (4) при $t \ge t_1$ в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Разработка новой математической модели при формировании иерархии математических моделей объекта исследования может привести к уточнению найденных ранее условий применимости построенных математических моделей. Действительно, используя математическую модель (7), можно уточнить условие применимости формулы (3). Для этого найдем момент времени

$$t_1^* = t_0 + \frac{c_1}{\alpha_1 S_1}\left[\left(\frac{\gamma_1}{\beta_1}\frac{U - r_1 I_*}{2U - r_1 I_*}\frac{U}{r_1 I_*} + \right.\right.$$

$$\left.\left. + \frac{U}{2U - r_1 I_*} - 1\right)\ln\left(1 + \frac{r_1 I_*}{U}\delta_0\right) -\right.$$

$$-\left(\frac{U}{2U-r_1I_*}+\frac{\gamma_1}{\beta_1}\frac{U-r_1I_*}{2U-r_1I_*}\frac{U}{r_1I_*}\right)\times$$

$$\times\ln\left(1-\frac{r_1I_*}{U-r_1I_*}\delta_0\right)-\frac{\gamma_1}{\beta_1}\delta_0\Bigg],$$

для которого

$$I_1\left(t_1^*\right)=\frac{I_0}{1+\delta_0}.$$

Очевидно, что при $t\le t_1^*$

$$\delta\left(I_0\right)=\left|\frac{I_1-I_0}{I_1}\right|=\frac{I_0}{I_1}-1\le\delta_0,$$

а значение I_0 можно с относительной погрешностью не более δ_0 считать равным $I_1(t)$. Следовательно, можно с относительной погрешностью не более δ_0 использовать формулу (3) для нахождения искомой величины. Это позволяет сформулировать утверждение об использовании математической модели (3).

Утверждение 2. Если выполнено условие (6) или $t\le t_1^*$, то математическая модель макроуровня (3) в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Тогда применительно к построенной иерархии математических моделей данного объекта исследования справедливо следующее утверждение об использовании математической модели (7).

Утверждение 3. Если не выполнено условие (6), то математическая модель макроуровня (7) при $t_1^*<t<t_1$ в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

2.3. Решение задачи при $n > 1$

Пусть техническая система включает несколько параллельно соединенных терморезисторов. Для решения поставленной задачи используем полученные результаты при $n=1$. Они позволяют легко построить иерархию математических моделей макроуровня объекта исследования и определить условия, при выполнении которых можно с относительной погрешностью не более заданного значения δ_0 найти искомую величину I.

Если разности

$$T_1-T_0,\ldots,T_n-T_0$$

достаточно малы, то согласно (1) найдем искомую величину по формуле

$$I_0=U\sum_{i=1}^{n}r_i^{-1}. \qquad (8)$$

Определим условия, при которых применима полученная формула. Для этого рассмотрим установившийся процесс теплообмена. В этом случае согласно (4) и (5) установившееся значение величины I_i найдем по формуле

$$I_i^*=\frac{2U}{r_i\left[1+\sqrt{1+4\beta_iU^2\alpha_i^{-1}S_i^{-1}r_i^{-1}}\right]},$$

причем для данного диапазона температур

$$\frac{U^2}{\alpha_iS_ir_i\left(T^*-T_0\right)}\le1+\beta_i\left(T^*-T_0\right). \qquad (9)$$

Тогда установившееся значение искомой величины равно

$$I_*=\sum_{i=1}^{n}I_i^*. \qquad (10)$$

Для относительной погрешности величины I_0 запишем

$$\delta\left(I_0\right)=\left|\frac{I-I_0}{I}\right|=\frac{I_0}{I}-1\le\frac{I_0}{I_*}-1.$$

При выполнении неравенства

$$\frac{I_0}{I_*}-1\le\delta_0$$

можно с относительной погрешностью не более δ_0 использовать формулу (8) для нахождения искомой величины. Следовательно, при выполнении неравенства

$$I_0\le\left(1+\delta_0\right)I_* \qquad (11)$$

математическая модель макроуровня (8) в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Затем определим условия, при которых применима математическая модель (10). Для этого рассмотрим неустановившийся процесс теплообмена. Тогда согласно (7) приходим к задаче Коши

$$\frac{c_iU}{\beta_ir_iI_i^2}\frac{dI_i}{dt}=\frac{\alpha_iS_iU-\alpha_iS_ir_iI_i-\beta_ir_iUI_i^2}{\gamma_iU-\gamma_ir_iI_i+\beta_ir_iI_i},$$

$$I_i\left(t_0\right)=Ur_i^{-1}, \qquad (12)$$

где $1\le i\le n$, и найдем момент времени

$$t_i=t_0+\frac{c_i}{\alpha_iS_i}\Bigg[\frac{\gamma_i}{\beta_i}\left(\frac{r_iI_i^*}{U}-1+\delta_0\right)\frac{U}{r_iI_i^*}+$$

$$+\left(\frac{U}{2U-r_iI_i^*}+\frac{\gamma_i}{\beta_i}\frac{U-r_iI_i^*}{2U-r_iI_i^*}\frac{U}{r_iI_i^*}-1\right)\times$$

$$\times\ln\left(2-\frac{r_iI_i^*}{U}-\delta_0\right)-\left(\frac{U}{2U-r_iI_i^*}+\right.$$

$$\left.+\frac{\gamma_i}{\beta_i}\frac{U-r_iI_i^*}{2U-r_iI_i^*}\frac{U}{r_iI_i^*}\right)\ln\left(\frac{U}{U-r_iI_i^*}\delta_0\right)\Bigg],$$

для которого

$$I_i\left(t_i\right)=\frac{I_i^*}{1-\delta_0}.$$

Очевидно, что при $t\ge t_i$

$$\delta\left(I_i^*\right)=\left|\frac{I_i-I_i^*}{I_i}\right|=1-\frac{I_i^*}{I_i}\le\delta_0,$$

а значение I_i^* можно с относительной погрешностью не более δ_0 считать равным $I_i(t)$. Пусть $t_*=\max\limits_{1\le i\le n}t_i$, тогда легко показать, что при $t\ge t_*$

$$\delta\left(I_*\right)=\left|\frac{I-I_*}{I}\right|=\frac{\sum\limits_{i=1}^{n}\left(I_i-I_i^*\right)}{\sum\limits_{i=1}^{n}I_i}\le\delta_0.$$

Следовательно, можно с относительной погрешностью не более δ_0 использовать формулу (10) для нахождения искомой величины. Это позволяет сформулировать следующее утверждение об использовании математической модели (10).

Утверждение 4. Если не выполнено условие (11), то математическая модель макроуровня (10) при $t\ge t_*$ в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Уточним условие применимости формулы (8), используя математическую модель (2), (12). Для этого найдем момент времени

$$t_i^*=t_0+\frac{c_i}{\alpha_i S_i}\left[\left(\frac{\gamma_i}{\beta_i}\frac{U-r_iI_i^*}{2U-r_iI_i^*}\frac{U}{r_iI_i^*}+\right.\right.$$
$$\left.+\frac{U}{2U-r_iI_i^*}-1\right)\ln\left(1+\frac{r_iI_i^*}{U}\delta_0\right)-$$
$$-\left(\frac{U}{2U-r_iI_i^*}+\frac{\gamma_i}{\beta_i}\frac{U-r_iI_i^*}{2U-r_iI_i^*}\frac{U}{r_iI_i^*}\right)\times$$
$$\left.\times\ln\left(1-\frac{r_iI_i^*}{U-r_iI_i^*}\delta_0\right)-\frac{\gamma_i}{\beta_i}\delta_0\right],$$

для которого

$$I_i\left(t_i^*\right)=\frac{U}{r_i\left(1+\delta_0\right)}.$$

Очевидно, что при $t\le t_i^*$

$$\delta\left(Ur_i^{-1}\right)=\left|\frac{I_i-Ur_i^{-1}}{I_i}\right|=\frac{U}{r_iI_i}-1\le\delta_0,$$

а значение Ur_i^{-1} можно с относительной погрешностью не более δ_0 считать равным $I_i(t)$. Пусть $t^*=\min\limits_{1\le i\le n}t_i^*$, тогда легко показать, что при $t\le t^*$

$$\delta\left(I_0\right)=\left|\frac{I-I_0}{I}\right|=\frac{\sum\limits_{i=1}^{n}\left(Ur_i^{-1}-I_i\right)}{\sum\limits_{i=1}^{n}I_i}\le\delta_0.$$

Следовательно, можно с относительной погрешностью не более δ_0 использовать формулу (8) для нахождения искомой величины. Это позволяет сформулировать утверждение об использовании математической модели (8).

Утверждение 5. Если выполнено условие (11) или $t\le t^*$, то математическая модель макроуровня (8) в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

Тогда применительно к построенной иерархии математических моделей данного объекта исследования справедливо следующее утверждение об использовании математической модели (2), (12).

Утверждение 6. Если не выполнено условие (11), то математическая модель макроуровня (2), (12) при $t^*<t<t_*$ в достаточной мере обладает свойствами полноты, адекватности, продуктивности и экономичности.

2.4. Выводы

Построение иерархии математических моделей макроуровня объекта исследования при выполнении неравенства (9) позволяет выявить математическую модель макроуровня, которая в достаточной мере обладает нужными свойствами применительно к конкретному исследованию, а исследователь получает ценный интеллектуальный продукт — эквивалент изучаемого объекта для рассматриваемого им частного случая. Действительно, если выполнено условие (11) или в рамках проводимого исследования $t\le t^*$, то математическую модель макроуровня (8) рассматриваем как пригодную математическую модель. Если не выполнено условие (11), то при $t\ge t_*$ выбираем математическую модель (10). В противном случае пригодной математической моделью считаем математическую модель макроуровня (2), (12).

Очевидно, что применение пригодной математической модели приводит к сокращению затрат времени и средств на проведение исследования, позволяет рационально использовать возможности математического моделирования.

Заключение

Преподавание математического моделирования с учетом изложенных теоретических и методологических особенностей не требует существенной корректировки содержания дисциплины, специальной организации учебного процесса. Необходимые прикладные задачи могут быть легко получены из уже существующих задач. Однако реализация таких особенностей развивает личностные

качества и индивидуальные способности обучающихся, создает условия для повышения уровня математической подготовки как отдельного обучающегося, так и группы в целом, формирует общую и неразрывную связь между изучаемыми дисциплинами, улучшает качество подготовки обучающихся к будущей профессиональной деятельности в условиях быстро изменяющегося мира.

Статья может быть полезной не только преподавателям и учителям, которые применяют элементы математического моделирования, но и широкому кругу читателей, заинтересованных в использовании возможностей математического моделирования.

References:

1. De Marchi, S. (2005). *Computational and Mathematical Modeling in the Social Sciences.* Cambridge University Press.
2. Cristini, V., & Lowengrub, J. (2010). *Multiscale Modeling of Cancer: An Integrated Experimental and Mathematical Modeling Approach.* Cambridge University Press.
3. Lewandowsky, S., & Farrell, S. (2011). *Computational Modeling in Cognition: Principles and Practice.* SAGE.
4. Hoppitt, W., & Laland, K. N. (2013). *Social Learning: An Introduction to Mechanisms, Methods, and Models.* Princeton University Press.
5. Fennel, W., & Neumann, T. (2015). *Introduction to the Modelling of Marine Ecosystems.* Elsevier.
6. Eraslan, A., & Kant, S. (2015). Modeling Processes of 4th-Year Middle-School Students and the Difficulties Encountered. *Kuram ve Uygulamada Egitim Bilimleri, 15*(3), 809–824. https://doi.org/10.12738/estp.2015.3.2556
7. Krutikhina, M. V., Vlasova, V. K., Galushkin, A. A., & Pavlushin, A. A. (2018). Teaching of Mathematical Modeling Elements in the Mathematics Course of the Secondary School. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(4), 1305–1315. https://doi.org/10.29333/ejmste/83561
8. Anhalt, C. O., & Cortez, R. (2016). Developing Understanding of Mathematical Modeling in Secondary Teacher Preparation. *Journal of Mathematics Teacher Education, 19*(6), 523–545. https://doi.org/10.1007/s10857-015-9309-8
9. Fedoseyev, V. M. (2016). Involving Students in Research as a Form of Integration of Engineering with Mathematical Education. *Integration of Education, 20*(1), 125–133. https://doi.org/10.15507/1991-9468.082.020.201601.125-133
10. Czocher, J. A. (2017). How can Emphasizing Mathematical Modeling Principles Benefit Students in a Traditionally Taught Differential Equations Course? *Journal of Mathematical Behavior, 45*, 78–94. https://doi.org/10.1016/j.jmathb.2016.10.006
11. Shilova, Z. V., & Sibgatullina, T. V. (2017). Methodology Features of Teaching Stochastics to University Students of the Biology Specialization. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(8), 4725–4738. https://doi.org/10.12973/eurasia.2017.00960a
12. Kim, S. H., & Kim, S. (2010). The Effects of Mathematical Modeling on Creative Production Ability and Self-Directed Learning Attitude. *Asia Pacific Education Review, 11*(2), 109–120. https://doi.org/10.1007/s12564-009-9052-x
13. Larripa, K. R., & Mazzag, B. (2016). A Modular Approach to Teaching Mathematical Modeling in Biotechnology in the Undergraduate Curriculum. *PRIMUS, 26*(5), 485–504. https://doi.org/10.1080/10511970.2015.1104524
14. Seshaiyer, P. (2017). Leading Undergraduate Research Projects in Mathematical Modeling. *PRIMUS, 27*(4–5), 476–493. https://doi.org/10.1080/10511970.2016.1240732
15. Anhalt, C. O., Cortez, R., & Bennett, A. B. (2018). The Emergence of Mathematical Modeling Competencies: An Investigation of Prospective Secondary Mathematics Teachers. *Mathematical Thinking and Learning, 20*(3), 202–221. https://doi.org/10.1080/10986065.2018.1474532
16. Samarskii, A. A., & Mikhailov, A. P. (2002). *Principles of Mathematical Modeling: Ideas, Methods, Examples.* Taylor & Francis.
17. Dym, C. L. (2004). *Principles of Mathematical Modeling.* Elsevier Academic Press.
18. Velten, K. (2009). *Mathematical Modeling and Simulation: Introduction for Scientists and Engineers.* Wiley-VCH.

19. Meerschaert, M. M. (2013). *Mathematical Modeling.* Academic Press.
20. Markelov, G. Ye. (2005). Basic Principles to Construct Mathematical Models. *Herald of the Bauman Moscow State Technical University, Series Natural Sciences*, (4), 59–70.

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	GIF (Australia)	= 0.564	ESJI (KZ)	= 8.771	IBI (India)	= 4.260
	JIF	= 1.500	SJIF (Morocco)	= 7.184	OAJI (USA)	= 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 06.02.2024 **http://T-Science.org**

Issue Article

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FACTORS AFFECTING MARRIED WOMEN'S WORK PARTICIPATION IN THE PROCESSING INDUSTRY SECTOR IN PELALAWAN DISTRICT

Abstract: *This study was conducted to determine the effect of wage level, education level, age, husband's income level and expenditure level on married women's work participation in the manufacturing industry sector in Pelalawan Regency. In addition, the study aimed to identify the most influential variables among these factors on married women's work participation in the same sector and region. This study used a special sampling method, with a total of 64 respondents, and data analysis was conducted using multiple linear regression assisted by Eviews 10 software program. The research findings show that collective wage rate, education level, age, husband's income level and expenditure level have a statistically significant effect on the labor participation of married women in the manufacturing industry sector in Pelalawan Regency. Individually, wage level (X1) has a significant and positive effect on married women's work participation, education level (X2) has a significant and positive effect on married women's work participation, while age (X3) has a significant and negative effect on married women's work participation. Similarly, husband's income level (X4) has a significant and negative influence on married women's work participation and expenditure level (X5) has a significant and negative influence on married women's work participation. Among the five independent variables, education level is the most dominating factor affecting married women's work participation in the manufacturing industry sector in Pelalawan Regency. The cumulative effect (R2) of these three variables on the dependent variable is 63%, and the remaining 37% is influenced by other variables that have not been examined in this study.*

Key words: *Participation, Women, Industry.*

Language: *English*

Citation: Sari, L., Kurniasih, C. E., Taryono, Eriyati, & Rhahim, R. O. V. (2024). Factors affecting married women's work participation in the processing industry sector in Pelalawan district. *ISJ Theoretical & Applied Science, 02 (130),* 26-34.

Soi: http://s-o-i.org/1.1/TAS-02-130-4 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.4

Scopus ASCC*: 3300.*

Introduction

National development aims to create quality human resources. Improvements in women's quality of life can be achieved through development in the labor market. Women have taken on the role of the labor market in Indonesia as part of human resources, and have made a major contribution. According to data from the Indonesian Central Bureau of Statistics (2023) in August 2021, the labor force participation rate (TPAK) for men reached 83.87 percent, while the TPAK for women reached 53.41 percent. Although the labor force participation rate of men remains higher than that of women, there has been a significant increase in women's TPAK from 53.34 percent in 2021 to 53.41 percent in 2022.

The high number of women entering the labor market has a positive impact on economic growth, because it provides a positive response to the increase in the number of available workers, as stated (Maryam, 2021). The abundant availability of labor not only encourages economic growth, but is also the result of economic development itself. As mentioned by Malik (2016), during the period from 1970 to 2000, Indonesia experienced structural changes in its economy towards a sector that was more oriented towards the non-agrarian sector. These changes also affect the employment structure and job opportunities in the country.

The role of the agricultural sector in national production or gross domestic product (GDP) tends to continue to decline, replaced by the trade and services sector as well as the industrial sector which continues to experience significant increases. According to Mc Cawley in (Sumilat & Wahyuni, 2020) around 80% of the workforce in the industrial sector lives in rural areas, and almost halfthe majority of these workers are women. Apart from that, Pelalawan Regency is also experiencing a change in economic structure from the agricultural sector to the industrial sector.

Pelalawan Regency, which is located in Riau Province, has an economy dominated by sectors such as processing industry, agriculture, forestry, plantations, wholesale trade and retail. The economic structure in this region is greatly influenced by the role of these sectors in the production of goods and services. In 2021, the two sectors that dominate are the processing industry, which reaches 48.40 percent, and the agriculture, forestry and fisheries sector at 41.13 percent. However, in 2022, the processing industry will increase to 49.14 percent, while the agriculture, forestry and fisheries sectors will decrease to 39.95 percent (Pelalawan Central Statistics Agency, 2022).

The growth of the processing industry sector has experienced rapid development and has had an impact on increasing labor participation in this sector. The job opportunities available in this industrial sector also encourage women to join the workforce (Teja 2015). This can be seen from women's work participation which is lower than men's work participation. When compared with other areas in Riau Province, Pelalawan Regency has the lowest absorption capacity for women in the processing industry sector.

According to the Indonesian Central Statistics Agency (2023), male labor participation in the processing industry sector in 2022 will reach 11,000 people, while women will only be around 1,897 people. The low number of female workers in the processing industry sector indicates limited employment opportunities for women. The structure of the female workforce is closely related to changes in economic structure, which is based on added value (GRDP) and reflects regional dependence on various production sectors.

The number of female workers in the processing industry sector in Pelalawan Regency in 2022 in the large industrial sector is 242 people, medium industry is 398 people, then small industry is 1,184 people and household industry is 73 people (Department of Manpower and Riau Province Transmigration, 2023). According to the Pelalawan Central Statistics Agency (2022), large industry makes the largest contribution to the GRDP of Pelalawan Regency, because there is the Crude Palm Oil (CPO) industrial sector and the pulp and paper pulp industry which supports the large industrial sector. Data on female workers is based on 23 companies in the Crude Palm Oil (CPO) industrial sector and the pulp and paper pulp industry in Pelalawan Regency.

Many women involved in large industrial sectors are influenced by various factors. Firstly, the wage factor, where high wages offered by the labor market certainly encourage someone to enter the labor market (Uppun, P., & Ramadhan 2022). The wages women earn can be used to supplement and meet their daily needs.

Second, the educational factor, which involves an element of prestige, especially for highly educated women who see work as a means to prove or actualize themselves (Putri and Purwanti 2012). Women currently have better access to education, so that more women who have a good education will have greater job opportunities.

Apart from educational factors, productive age factors also encourage married women to enter the labor market (Rochmawati et all., 2018). Based on the

Pelalawan Central Statistics Agency (2023), the highest level of female work participation occurs in the 35-44 year age group. Meanwhile, the work participation rate of women in the 55-60+ year age group is lower, this is due to the fact that in the 40-60 year age range, women's work productivity tends to decline. According to Annazah (2021), the older a woman is, the greater her risk of experiencing health problems, but on the contrary, young women tend to be more likely to choose to work compared to older women. Therefore, good management of the productive age group can have a positive impact on the country's economic performance.

Economic factors also play a role in the decisionwomen to work, especially if the household economic conditions are low and the husband's income is deemed insufficient for the family's needs. Therefore, women look for work to increase household income (Handayani et al., 2020). A husband's income can be measured by the district/city minimum wage, which is an important indicator in determining a person's income level.

According to data from the Pelalawan Regency Central Statistics Agency in 2022, it appears that every year the minimum wage in Pelalawan Regency has increased, and in 2023, the minimum wage in Pelalawan Regency will reach IDR 3,287,623. The minimum wage level received by a person reflects the individual's income level and consumption level.

Married women's work participation often relies on their husband's ability to generate income. A married woman's decision to work is greatly influenced by her husband's income level. Wives usually work harder to help with household costs if they feel their husband's income is still insufficient, to help meet household needs (Dewi, 2018).

Household expenditure is also an economic factor that influences women's work participation, the greater the level of household expenditure, the higher the work participation rate of married women (Direja 2021). The number of dependents in the family will influence the amount of family expenses, in this case family needs.

Household expenses are influenced by the number of family members, the greater the number of family members who have to support the greater the household expenses. Having large household expenses that must be met, the wife feels the need to increase her working hours.

Factors that influence the work participation of married women in the processing industry sector in Pelalawan district include wage level, education level, age, husband's income level and expenditure level.

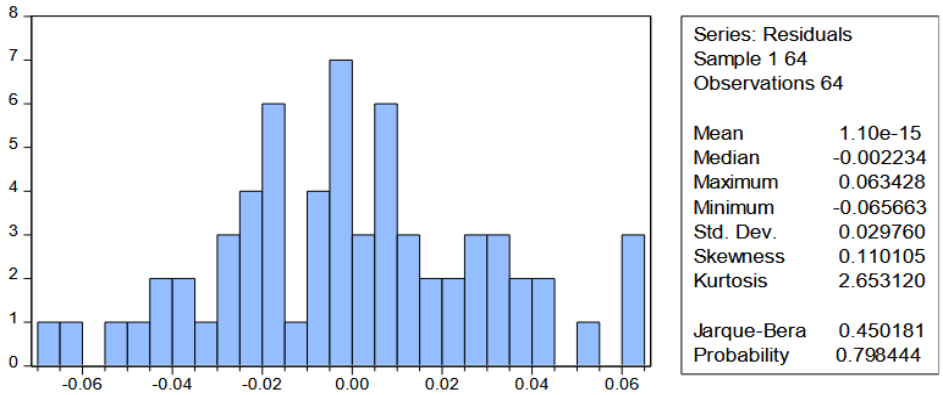
RESEARCH METHODS

The research involved a population of research subjects consisting of 189 female workers who worked in five large industrial companies in Pelalawan Regency. The sampling method used in the research is purposive sampling, which is included in the non-probability sampling category. The sample used in this research was 64 women who were married and worked in five large companies, located in Pelalawan Regency. The research methodology applied is a quantitative approach, using primary and secondary data. One method used by researchers to collect data is through the use of questionnaires. In this research, cross section data is used to analyze multiple linear regression using the Ordinary Least Squares (OLS) method. Multiple linear regression analysis is used to assess the correlation between two or more independent variables and the dependent variable (Y) (Wirawan 2017).

RESULTS AND DISCUSSION

Normality Test Results

The normality test is used to evaluate the distribution of data in the variables used in the research. When checking the assumption of normality, the Jarque-Bera (JB) test was used. If the calculated JB probability exceeds 0.05, then the data is considered to have a distribution that is close to normal. However, if the calculated JB probability is less than 0.05, then the data is considered not to follow a normal distribution (August 2015). The results of normality testing using the Jarque-Bera test can be seen in Picture 1.



Picture 1. Normality Test.

Source: Eviews Data Processing Results, 2023

Judging from the results of the previous normality test, it can be concluded that the Jarque-probability of 0.798444 exceeds the threshold of 0.05, which indicates that the data in this research variable can be considered to follow a normal distribution.

Variables	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.500730	33312.36	NA
LOG(WAGE)	0.002504	40594.99	1.337276
LOG(EDUCATION)	0.005703	2924.242	1.486193
LOG(AGE)	0.000968	816.6302	1.608291
LOG(SUAM_REVENUEI)	0.000546	8707.589	1.364107
LOG(EXPENSE_HOUSEHOLD)	0.000886	13939.48	1.397497

Table 1. Multicollinearity Test Results
Variance Inflation Factors
Sample: 1 64

Source: Eviews 2023 Data Processing Results

Multicollinearity Test Results

According to Ghozali (2016) the purpose of the multicollinearity test is to find out whether the independent variables in the regression model are correlated with each other. Variance Inflation Factor (VIF) is a technique used to assess multicollinearity. Table 1 shows that if the VIF value is less than 10, then there is no evidence of a multicollinearity problem.

Table 1 shows that each variable in this study has a VIF (Variance Inflation Factor) which is below 10. Wage level has a VIF of 1.337276, education level of 1.486193, age of 1.608291, husband's income level of 1.364107 and household expenditure level of 1.397497 . From these results, there is no multicollinearity between the independent variables. As a result, the data in this study met the requirements of the multicollinearity test.

Heteroscedasticity Test Results (Glejser)

The heteroscedasticity test is carried out to determine whether there is inequality in the residual variance from one observation to another in the regression model (Ghozali 2016). Decisions in the heteroscedasticity test are taken based on a probability greater than the significance level (0.05), which indicates that the model does not experience heteroscedasticity.

Table 2. Heteroscedasticity Test Results (Glejser)
Heteroskedasticity Test: Glejser

F-statistic	2.156468	Prob. F(5,58)	0.0714
Obs*R-squared	10.03266	Prob. Chi-Square(5)	0.0743
Scaled explained SS	9.168872	Prob. Chi-Square(5)	0.1025

Source: Eviews Data Processing Results, 2023

Based on table 2 it is known that the valueThe chi-square probability is 0.0743 > 0.05, so it can be stated that in this regression, there is no heteroscedasticity problem.

Multiple Linear Regression Results

Table 3. Multiple Linear Regression Results

Dependent Variable: LOG (PEREMPUAN_WORK PARTICIPATION)

Method: Least Squares

Variables	Coefficient	Std. Error	t-Statistics	Prob.
C	3.597451	0.707623	5.083854	0.0000
LOG(WAGE)	0.134445	0.050039	2.686833	0.0094
LOG(EDUCATION)	0.284165	0.075519	3.762828	0.0004
LOG(AGE)	-0.147119	0.031118	-4.727838	0.0000
LOG(HUSBAND'S_INCOME)	-0.076012	0.023369	-3.252711	0.0019
LOG(HOME_EXPENSESLADDER)	-0.059659	0.029762	-2.004549	0.0497
ıared	0.706118	ı dependent var		3.867436
sted R-squared	0.680783	ependentvar		0.054897
' regression	0.031016	‹e info criterion		-4.019552
squared resid	0.055796	'arz criterion		-3.817156
ikelihood	134.6257	an-Quinn Criter.		-3.939818
tistic	27.87162	in-Watson stat		2.195111
(F-statistic)	0.000000			

Source: Eviews Data Processing Results, 2023

The results of this research identify variables that have an impact on married women's work participation in the processing industry sector in Pelalawan Regency, as documented in table 3. The following are the results of the multiple linear regression analysis in this research:

LogY = 3.597451 + 0.134445**LogX1** + 0.284165**LogX2** – 0.147119**LogX3** – 0.076012**LogX4** – 0.059659**LogX5**

Based on the equations in the multiple linear regression results in Table 3, we can interpret them as follows:

a. The constant value is 3.597451. This shows that if all independent factors are considered constant or fixed, then the work participation of married women in the processing industry sector in Pelalawan Regency is around 3.597451%.

b. The coefficient value for the wage level variable (X1) is positive at 0.134445. The results of this coefficient indicate that an increase in wage levels of 1% will result in an increase in the participation of married women working in the processing industry sector by around 0.134445%.

c. The coefficient value for the education level variable (X2) is positive at 0.284165. The results of this coefficient indicate that an increase in education level of 1% will result in an increase in the participation of married women working in the processing industry sector by around 0.284165%.

d. The coefficient for the age variable (X3) has a negative value of -0.147119. This illustrates that every 1% increase in the age of married women will reduce the work participation of married women in the processing industry sector by around 0.147119%.

e. The coefficient value of the husband's income level (X4) has a negative coefficient value of -0.076012. The results of this coefficient show that every 1% increase in the husband's income level will reduce the work participation of married women in the processing industry sector by 0.076012%.

f. The coefficient value of household expenditure level (X5) has a negative coefficient value of - 0.059659. The results of this coefficient show that every 1% increase in household expenditure levels will reduce the work participation of married women in the processing industry sector by 0.059659%.

Coefficient of Determination Results (R2)

The coefficient of determination is usedto measure how big or far the independent variable is from the dependent variable. The coefficient of determination has a value of 0.680783 according to the results of multiple linear regression analysis which can be seen in table 3. This means that around 68 percent of the variation in married women's work participation in the processing industry sector in Pelalawan Regency can be explained by the wage level variable, education level, age, husband's income level and expenditure level have been included in this regression model. Meanwhile, the remaining 32 percent is influenced by other factors not included in this regression model.

Simultaneous Test Results (F Test)

The F test is used to assess the influence of independent factors on the dependent variable together. The significance level of this test has been set at 5% or 0.05. The F test probability value of 0.0000 is less than 0.05 based on the findings of multiple linear regression analysis in table 3. Therefore, it can be concluded that the variables wage level, education level, age, husband's income level and expenditure level together have significant influence

on the work participation of married women in the processing industry sector in Pelalawan Regency.

Partial Test Results (t Test)

This test uses significance criteria, where a significance value of less than 0.05 indicates a significant influence between the independent variable and the dependent variable. The following are the results of the multiple linear regression analysis in Table 3:

1. Wage Level has a significance value of 0.0094 <0.05, so it can be concluded that the wage level variable partially has a significant effect on the work participation of married women in the processing industry sector in Pelalawan Regency.
2. Education level has a significance value of 0.0004 <0.05, so it can be concluded that the variable level of education partially has a significant effect on the work participation of married women in the processing industry sector in Pelalawan Regency.
3. Age has a significance value of 0.0000 <0.05, so the Age variable partially has a significant effect on the work participation of married women in the processing industry sector in Pelalawan Regency.
4. The significance level for the husband's income level variable is 0.0019 <0.05. Therefore, partially the husband's income level variable has a significant effect on the work participation of married women in the processing industry sector in Pelalawan Regency.
5. The significance level for the husband's income level variable is 0.0497 <0.05. Therefore, partially the husband's income level variable has a significant effect on the work participation of married women in the processing industry sector in Pelalawan Regency.

Discussion

The Influence of Variables: Wage Level, Education Level, Age, Husband's Income Level, and Expenditure Level Simultaneously

The research results show that simultaneously, the husband's education level, age and income level influence the work participation of married women in the processing industry sector of Pelalawan Regency, with a probability F value of 0.0000 which is lower than 0.05. This confirms that the husband's education level, age and income level have a significant influence on the work participation of married women in the processing industry sector of Pelalawan Regency.

Research by Klasen et al., (2020) shows a number of factors that influence changes in women's participation rates in the labor market. In a number of countries, including Blovia, Brazil, India, Jordan, South Africa, Tanzania, and Vietnam, they conducted comparative comparisons. Their study findings show that the main determinants influencing the level of women's involvement in the labor market include disparities in women's and family characteristics, as well as social, institutional, and economic barriers. In addition, education level, age and income have a significant influence on married women's work participation, especially in countries with lower economic levels.

The Influence of Wage Level Variables on Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

The results of the analysis in this study reveal that the work participation of married women in the processing industry sector in Pelalawan Regency is influenced positively and significantly by the education level variable. This can be seen from the positive coefficient value of 0.134445 and the significant probability F, which is 0.0094 which is less than 0.05. The results of this coefficient indicate that the work participation of married women in the processing industry sector in Pelalawan Regency will increase along with higher wage levels. Increasing the wife's income helps the husband to meet the family's needs.

According to neo-classical economic theory, it is explained that women's participation in the labor market depends on the variable wages offered. If the market offers high wages (exceeding expected expectations) then women's participation in the labor market will increase (Maryam 2021).

Explanations in the research also reveal that the reason married female workers work in the processing industry sector in Pelalawan Regency is that the wages offered by the company are very high. The high wages earned by wives help to meet the family's needs. The results of this research are in line with Purwanti, E., & Rohayati (2015) who stated that increasing the income level of female workers, their work participation will also increase, the income of female workers obtained from the work of female workers is influenced by the level of participation of women themselves. in work.

The Influence of Educational Level Variables on Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

The results of the analysis in this study reveal that the work participation of married women in the processing industry sector in Pelalawan Regency is influenced positively and significantly by the education level variable. This can be seen from the positive coefficient value of 0.284165 and the significant probability F of 0.0004 which is less than 0.05. The results of this coefficient indicate that the work participation of married women in the processing industry sector in Pelalawan Regency will increase along with higher levels of education. This can increase married women's income and improve overall welfare.

In the formal sector in large companies in the processing industry sector of Pelalawan Regency, the

education pursued by female workers is a major concern. On average, married female workers complete their final education within a period of 16-18 years in the processing industry sector of Pelalawan Regency. This shows that education is very important to form knowledge and work experience which can later improve skills. With skills, companies expect good and increased productivity from the workforce.

The Influence of Age on Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

The results of the analysis in this study reveal that the age variable has a significant and negative influence on the work participation of married women in the processing industry sector in Pelalawan Regency. This result can be seen from the probability that F is significant at 0.0000, which is less than 0.05, and the negative coefficient value is -0.147119. The results of this coefficient indicate that the older married women are, the more their work participation in the processing industry sector in Pelalawan Regency will decrease.

Dwi (2020) also explains that work participation tends to decline after reaching old age. This is in accordance with the fact that at that age, many people enter retirement and may be physically unable to work anymore. In research, Berliana and Lukmi (2016) also support this finding by showing that women who are married and older have a lower probability of working more than 40 hours a week.

These results are related to the characteristics of the respondents, married women who work in the processing industry sector are predominantly in the 33-35 year age range which is classified as productive age. The decline in work participation at older ages can be caused by the decline in productivity that usually occurs with increasing age and declining health conditions.

The Influence of Husband's Income Level on Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

The results of the analysis in this research include the husband's income level variable which has a significant and negative influence on the work participation of married women in the processing industry sector in Pelalawan Regency. This can be seen from the significance of the F probability which reaches 0.0019, which is smaller than 0.05, as well as the negative coefficient value of -0.076012. The results of this coefficient indicate that the higher the husband's income, the lower the work participation of married women in the processing industry sector in Pelalawan Regency.

Explanations in the research also reveal that the reason married female workers work in the processing industry sector in Pelalawan Regency is to meet family or household needs. The high needs of the family and the increase in prices of goods which are not always matched by an increase in income cause wives to help their husbands in earning a living for the family. A husband's ability to generate income has a major impact on how much married women participate in the labor market. Wives will work to help with household costs if their husband's income is still insufficient, as revealed in research by (Epinda, et all 2021).

The Influence of Expenditure Levels on Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

The results of the analysis in this research variable level of expenditure have a significant and negative influence on the work participation of married women in the processing industry sector in Pelalawan Regency. This can be seen from the significance of the F probability which reaches 0.0497, which is smaller than 0.05, as well as the negative coefficient value of -0.059659. The results of this coefficient indicate that the higher the level of expenditure, the lower the work participation of married women in the processing industry sector in Pelalawan Regency.

The results of this research are not in line with Maryam's (2021) opinion that if the level of expenditure is high, the level of work participation will also increase. This is because household expenditure follows the needs of household members who are dependent on the household.

Women who work in the processing industry sector, especially large industries, on average have a small number of dependents so the costs they incur for education are not too large. The company also provides facilities such as houses, electricity, etc., so expenses do not become large.

Dominant Factors that Influence Married Women's Work Participation in the Processing Industry Sector in Pelalawan Regency

Based on the research results in table 3, it can be concluded that the largest regression coefficient is owned by the independent variable wage level (X1) of 0.134445, education level (X2) of 0.284165, while age (X3) has a coefficient of -0.147119, husband's income (X4) is -0.076012 and the expenditure level has a coefficient of -0.059659. The coefficient value shows that the education level variable has the strongest or dominating influence on the work participation of married women in the processing industry sector in Pelalawan Regency. This means that married women's work participation in the processing industry sector, especially large industries, tends to increase along with the increase in women's education level.

According to Sukarniati (2019), the dominant factor influencing work participation among married women is education. Increasing women's education

has also increased work participation among women, including married women. This result is also in line with the opinion according to Dwi (2020) that women who have a high level of education usually do not carry out household tasks at home, but rather participate in the labor market. The results of this study show that women are married and have an educational level those with higher education are more likely to choose to work compared to women with lower education. Additionally, women with higher educational backgrounds may have access to a wider variety of jobs, including greater flexibility in working hours.

According to Herlina (2020), the level of education on married women's employment opportunities has a higher significance coefficient than the influence of age, wages, husband's income and industrial sector. This shows that the role of education is very dominant in increasing the participation of married women in the labor market. Therefore, it is better to emphasize efforts to empower the younger generation of women by increasing access to education as preparation for a career in the processing industry sector, especially in large companies.

CONCLUSION

Based on the results of research on the work participation of married women in the processing industry sector in Pelalawan Regency, from the regression results that have been obtained, it can be concluded that simultaneously wage level, education level, age, husband's income level and expenditure level have a significant influence on women's work participation. who are married in this sector. Partially, wage levels and education levels have a positive and significant influence on the work participation of married women in the processing industry sector in Pelalawan Regency. Meanwhile, age, husband's income and level of expenditure have a negative and significant influence on married women's work participation in this sector.

The most dominant factor influencing married women's work participation in the processing industry sector in Pelalawan Regency is the education variable, because the high level of education of married women who work increases the probability of married women working and they are more likely to choose to work rather than stay at home to care. children and taking care of the household.

SUGGESTION

1. Companies are expected to be able to adjust the minimum wages set by the government.
2. The Pelalawan Regency government is expected to improve the quality of education and equal distribution of infrastructure related to education in order to expand employment opportunities for married women, especially in the processing industry sector in order to reduce the unemployment rate and the government should make it easier for married women who want and have the ability to work in companies and agencies.
3. It is hoped that the government and companies can select women of productive age to work in the processing industry and also provide special jobs that can be done by married women of productive age.
4. For future authors who want to research the same problem, they can also add new variables which are considered to also influence the work participation of married women in the processing industry sector in Pelalawan district.

References:

1. Agus, Tri Basuki. (2015). *Ekonometrika (teori&aplikasi)*. Yogyakarta: Mitra Pustaka murni.
2. Annazah, Nur Siti. (2021). “Faktor-Faktor Yang Mempengaruhi Wanita Menikah Berusia Produktif Untuk Bekerja Tahun 2019 (Studi Kasus Provinsi Jawa Barat).” *Jurnal Ketenagakerjaan* Vol 16(No.1).
3. (2023). Badan Pusat Statistik Indonesia. Badan Pusat Statistik Indonesia *Tingkat Partisipasi Angkatan Kerja (TPAK) (Persen)*. Jakarta: Badan Pusat Statistik Indonesia.
4. (2023a). Badan Pusat Statistik Pelalawan. *Kajian Ekonomi Sektoral Kabupaten Pelalawan 2021*. Pelalawan: Badan Pusat Statistik Pelalawan.
5. (2023b). *Statistik Daerah Kabupaten Pelalawan 2022*. Pelalawan: Badan Pusat Statistik Pelalawan.
6. Berliana, Sarni Maniar, dan Ana Purbasari Lukmi. (2016). “Faktor Faktor Yang Memengaruhi Jam Kerja Tenaga Kerja Wanita Berstatus Kawin Dalam Seminggu Di Indonesia (Analisis Data Sakernas 2014).” *Jurnal Ilmiah WIDYA* 3(4): 1–6.

7. Dewi, Made Ayu Laksmitha, dan Ni Putu Martini Dewi. (2018). "Pengaruh Umur, Pendidikan dan Jumlah Tanggungan Keluarga terhadap Pendapatan Pekerja Perempuan Sektor Informal di Kota Denpasar." *Jurnal EP Unud* Vol 7(No.1): 1–29.
8. Direja, Sukma. (2021). "Partisipasi Kerja Wanita Menikah Di Provinsi Banten Tahun 2020." *Jurnal IlmuEkonomi* Vol.11 (No. 1).
9. Dwi, Handoyo Rossanto. (2020). *Ekonomi Sumber Daya Manusia*. Tangerang Selatan: Universitas Terbuka.
10. Epinda, Bela Aulia, Ansofino, dan Meliza Sari Putri. (2021). "Pengaruh Tingkat Pendidikan, Umur, Jumlah Tanggungan Keluarga, Pendapatan Suami Dan Motivasi Terhadap Keputusan Wanita Untuk Bekerja Di Kecamatan Koto Salak Kabupaten Dharmasraya." *Jurnal Horizon Pendidikan* Vol.1 (No.2): 263–72.
11. Ghozali, Imam. (2016). *Aplikasi Analisis Multivariete Dengan Program (IBM SPSS)*. Semarang: Badan Penerbit Universitas Diponegoro.
12. Handayani, Rahmita, Syapsan, dan Hendro Ekwarso. (2020). "Analisis Faktor Yang Mempengaruhi Tenaga Kerja Perempuan Bekerja Di Sektor Informal Di Kota Pekanbaru." *Jurnal Akrab Juara* Vol.5 (No.4).
13. Herlina, Ellin. (2015). "Faktor-faktor yang Mempengaruhi Kesempatan Kerja Wanita dan Implikasinya terhadap Kesejahteraan Keluarga di Kabupaten Cirebon." *Jurnal Ekonomi Program Pascasarjana Universitas Borobudur* 18(2): 172–207. ejournal.borobudur.ac.id.
14. Klasen, Stephan, Tu Thi Ngoc Le, Janneke Pieters, dan Manuel Santos Silva. (2020). "Comparable Micro-level Evidence from Eight Developing and Emerging Economies." *Journal of DevelopmentStudies* 57(3): 1–26.
15. Malik, Nazaruddin. (2016). *Dinamika Pasar Tenaga Kerja*. Malang: UMM Press.
16. Maryam, Siti. (2021). *Ekonomi Sumber Daya Manusia dan Ketenagakerjaan dalam Implementasi PeranProduktif Studi Etnis Mbojo*. Yogyakarta: Bintang Pustaka Madani.
17. Purwanti, E., & Rohayati, E. (2015). "Pengaruh Jumlah Tanggungan Keluarga, Pendapatan Terhadap Partisipasi Kerja Tenaga Kerja Wanita Pada Industri Kerupuk Kedelai Di Tuntang, Kab Semarang." *Among Makarti* 7(1).
18. Putri, Nadia Maharani, dan Evi Yulia Purwanti. (2012). "Analisis Penawaran Tenaga Kerja Wanita Menikah Dan Faktor Yang Mempengaruhinya Di Kabupaten Brebes." *Juranl Ekonomi Dipenogoro* Vol.1 (No.1).
19. Rochmawati, Nur Fitria, Wahyu Hidayat Riyanto, dan Ida Nuraini. (2018). "Hubungan Tingkat Pendidikan, Usia, Dan Pengalaman Keja Terhadap Pendapatan Pekerja Wanita Pada Industri Kerajinan Dompet Ida Collection Di Desa Pulo Kecamatan Tempeh Kabupaten Lumajang." *Jurnal Ilmu Ekonomi* Vol.2 (N0.3): 399–408.
20. Sukarniati, Lestari. (2019). *Ekonomi Sumber Daya Manusia*. Yogyakarta: Deepublish.
21. Sumilat, Dimas Erik, dan Ekawati Sri Wahyuni. 2020. "Analisis Gender Rumah Tangga Tenaga KerjaPerempuan Dalam Sektor Industri Garmen Dengan Sistem Putting Out." *Jurnal Sains Komunikasi dan Pengembangan Masyarakat* Vol.4 (No.2).
22. Teja, Mohamad. (2015). "Pembangunan Untuk Kesejahteraan Masyarakat Di Kawasan Pesisir." *Jurnal Ekonomi Pembangunan* Vol.6 (No.1).
23. Uppun, P., & Ramadhan, S. (2022). "Determinan Jam Kerja Pengusaha Kuliner Kaki Lima diSungguminasa Kabupaten Gowa." *Jurnal Ekonomika dan Dinamika Sosial* 1(1): 57–75.
24. Wirawan, Nata. (2017). *Statistika Ekonomi dan Bisnis (Buku 2: Statsitika Inferensia)*. Denpasar: KerarasEmas.

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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 08.02.2024 **http://T-Science.org**

Issue Article

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IMPROVING AUDITING OF ENVIRONMENTAL COSTS OF NEW PROJECTS

Abstract: *This article discusses the issues of auditing environmental costs for new projects and their assessment using analytical methods.*

Key words: *investments, new investment project, environmentally oriented project, performance indicators of investment projects, environmental costs of new projects, audit of costs of new projects, analytical activities.*

Language: *English*

Citation: Ruzmamatov, A. K. (2024). Improving auditing of environmental costs of new projects. *ISJ Theoretical & Applied Science, 02 (130),* 35-40.

Soi: http://s-o-i.org/1.1/TAS-02-130-5 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.5

Scopus ASCC: *2000.*

Introduction

In the sustainable development of regions in our country, it is very important to organize productions with an in-depth study of the effectiveness of new projects from an economic and ecological point of view. In particular, the proper organization of production activities in the economy, ensuring the continuity and growth of new projects depends on the availability of resources. This is related to the adoption of management decisions on the selection of projects aimed at ensuring the harmony of economic and ecological systems in ensuring the stability of territories. In order to make such management decisions, a detailed audit opinion is required to determine the economic efficiency of new projects by taking into account environmental costs and performing analytical operations. The current environmental situation requires conducting an audit, taking into account not only the profit and cash flows, but also the environmental impact of the implementation of projects, when determining the effectiveness of new projects.

It should be noted that there are many ways to evaluate the financial efficiency of investment projects. The method considered in this work takes into account environmental factors and is extremely important for today. Because regardless of the scale of implementation of new projects, the problem of environmental assessment has become very urgent in Uzbekistan in recent years. In fact, in our country it is required to pay great attention to the environment and even a number of legal documents are being adopted. For example, starting from January 1, 2024, in the design of new objects that fall into category I and category II in terms of environmental impact, the implementation of state ecological and urban planning expertise of projects that do not include the installation of high-efficiency dust-gas cleaning equipment and (or) local water treatment facilities, and it is forbidden to accept completed objects for use without installing them.

Literature review

At a time when the effectiveness of new projects is an important factor in the sustainable development of territories, as well as becoming a solid ground for development, humanity is gaining new knowledge about investments, and now modern authors publish many formulations of the term "investment projects". For example, according to V. V. Bocharov, the object of an investment project is any project that requires a large amount of capital expenditure (both financial and labor) for the implementation of this project. Investment projects often differ from other projects that require less planning and resources in terms of mass and relatively higher costs.

The Law of the Republic of Uzbekistan on Investments and Investment Activities (December 25,

2019 No. ORQ-598) defines an investment project as a set of interrelated activities aimed at realizing or attracting investments for economic, social and other benefits. Also, according to this law, investment activity is a set of actions of investment activity subjects related to the implementation of investments, and an investor is an investment activity subject that invests its own funds and (or) loan funds or other investment resources involved in investment activity objects for the purpose of profit.

Any commercial organization invests its resources to acquire various types of assets needed to carry out its core activities. Business entities pursue different goals when deciding on the implementation of one or another investment project. Savchuk V. P. in the book "Preparation and analysis of investment projects" indicates three main goals for the implementation of an investment project: updating the material and technical base, creating new types of products and expanding the production capabilities of the enterprise.

Cash flow has always been a major focus of cost audits for new projects. But today's environmental problems require a slight change in the traditional assessment methodology. According to Wang Chun, a professor at the Faculty of Economics of the China University of Finance and Economics (Xianxi), the method that does not take into account the social and environmental impact of the company's activities is called "extensive".

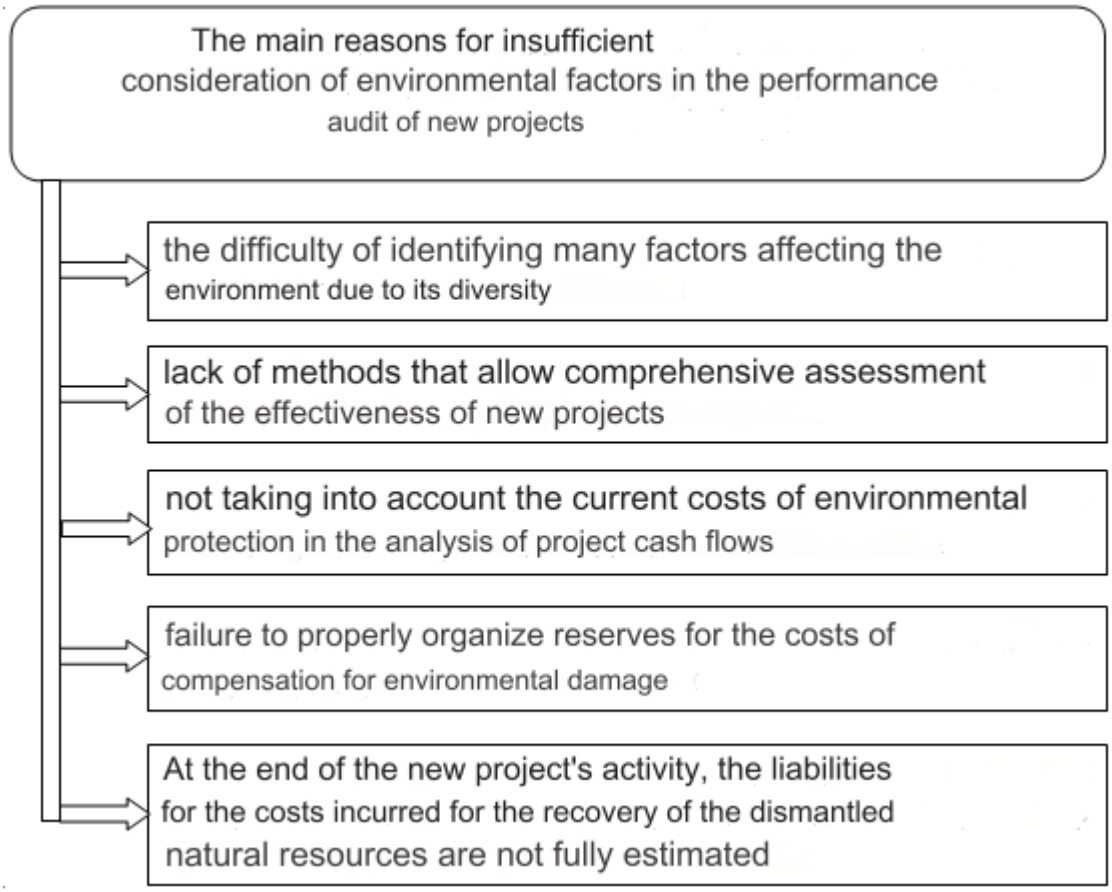
Research methodologys

In the study, the methods of economic analysis and statistical analysis used in national and international practice were used in the audit of investments in new projects and their important performance indicators, taking into account environmental costs.

Results and Discussion

Currently, the formation of a "green" economy and transition to its sustainable development is one of the priority tasks both globally and for Uzbekistan. The concept of sustainable development for the future of mankind is an important source, which is reflected in the resolutions and documents of the UN. The modern economy largely depends on compliance with environmental standards and orientation to the international concept of sustainable development. In the period of transition to economic development, the most important condition is an ecologically clean living environment. The implementation of new projects that play an important role in achieving strategic goals will affect it and the state of the ecological-economic system as a whole.

When conducting an audit on the evaluation of the effectiveness of large, socially significant projects, it is necessary to reveal additional information about the consequences of the project for the economy of the region and the country as a whole. In order to ensure sustainable development, it is important that project initiators, investors and permitting state organizations take into account the main aspects of investment projects - economic and environmental efficiency. Currently, the methods used to increase the responsibility of enterprises for environmental protection do not give the desired results. The following reasons can be given for insufficient consideration of environmental factors when conducting audits on the assessment of the effectiveness of new projects (Chart 1):



Drawing 1. Main reasons for insufficient consideration of environmental factors in performance audits of new projects

When conducting an audit on the evaluation of the effectiveness of new projects, expressing the results of environmental costs in monetary form and reflecting them in one cash flow allows:

- Determining the relationship between the amount of costs and the results of environmental protection activities;
- Determining the optimal level of the ratio of these indicators to achieve the required level of environmental safety of the project;
- Calculating the amount of economic benefit seen in the long-term strategy as a result of environmental costs;
- Determination of integrated cost-effectiveness indicators for environmental protection activities.

The listed cases determine the need to develop an economic-ecological assessment methodology when conducting an audit on the assessment of the effectiveness of investment projects. Such an assessment allows to determine the effectiveness of the project by calculating the consequences of the impact on the ecological environment in monetary terms and drawing a conclusion about the feasibility and possibilities of its implementation. It will be possible to determine the economic efficiency and priorities of the projects, and to assess the impact on the environment.

Businesses today must care not only about sales volume and profits, but also about minimizing the negative effects of production on the environment and have plans for environmental protection. In order to comply with environmental standards, project initiators need to use the latest equipment and regularly modernize the production process. The initiators of the project should take responsibility for maintaining a comfortable environment, rational use of natural resources, dismantling of equipment at the end of the project. Legal obligations to restore the environment can arise in two situations. First, it arises in connection with the requirements of the legislation of the area where the project is implemented, the contracts and license agreements concluded on the extraction of underground resources, and the terms of the project documents agreed with the state authorities. The second is constructive (voluntary) and can come from published environmental policies, past practices, management statements published in the media, etc. A liability for environmental remediation is recognized when it is probable that the remedial action will take place and the related costs can be measured reliably. There should usually be a formal

plan to recognize such a liability. Environmental obligations in new projects arise in two cases:

• during production activities;

• during project termination after the completion of the production process.

Of course, these actions and costs will affect the audit conclusion on cash flows, profits and losses, and the cost effectiveness of new projects, and ultimately the selection of projects.

Two methods are used for financial evaluation of economic efficiency of new projects - Non DFC (Non Discounted Cash Flow) and DCF (Discounted Cash Flow). The undiscounted cash flow method is a statistical valuation method that does not take into account changes in the value of money over time. And when evaluating project efficiency in terms of discounted cash flows, it takes into account the change in the value of money over time. The following indicators can be used when conducting an audit to assess the cost effectiveness of new projects:

- "normal" payback period (PP - Payback Period);

- discounted payback period (DPP - Discounted Payback Period);

- investment profitability coefficient (ROI — Return on Investment);

- coefficient of profitability index of investments (PI — Profitability Index);

- internal rate of return (IRR — Internal Rate of Return)

- net present value (NPV - Net Present Value).

Most methods for determining the economic efficiency of investment projects are based on the calculation of net present value (NPV). If we add the environmental costs of the project and the benefits from it based on the standard indicators used in the financial evaluation of the economic efficiency of the projects, we will get a new indicator of the financial evaluation of the economic efficiency of the projects - environmental net present value (ENPV - Environmental Net Present Value). Accordingly, even if NPV>0, the selection criteria for evaluating the economic efficiency of new projects taking into account environmental factors will be as follows: if ENPV>0, the project can be accepted; if ENPV<0, the project should be rejected. When choosing between two mutually exclusive projects, the project with the highest ENPV should be chosen. Below, we consider the role of the environmental net present value (ENPV) indicator in the financial assessment of economic efficiency in the audit of new project costs using an example:

Table 1. Information on calculation of NPV and ENPV indicators for a new project, in USD

Period	Net cash flow excluding environmental costs	Net current environmental costs	Net cash flow including environmental costs	NPV	ENPV
0 years	-5,300,000		-5,800,000		
1 year	470,402	30,000	440,402	-4,866,450	-5,394,100
2 years	998,653	60,000	938,653	-4,018,139	-4,596,756
3 years	1,179,695	70,000	1,109,695	-3,094,547	-3,727,967
4 years	1,268,734	80,000	1,188,734	-2,179,060	-2,870,207
5 years	1,358,763	90,000	1,268,763	-1,275,421	-2,026,422
6 years	1,357,774	100,000	1,257,774	-443,180	-1,255,475
7 years	1,539,805	110,000	1,429,805	426,696	-447,741
Total	**8,173,826**	**540,000**	**7,633,826**	**426,696**	**-447,741**

The investment at the beginning of the project is 5,300,000 USD, and the environmental costs at the beginning of the project are 500,000 USD, the discount rate is 8.5%.

From the data in the table, it can be seen that even if the NPV is positive (426,696), the project should be rejected because the environmental net present value ENPV is negative (-447,741), which means that the project is not economically efficient considering the environmental costs.

When new projects start operating in accordance with environmental standards, their costs will certainly increase, but such projects may be supported by the state and given a number of benefits and reliefs. Also, if the project initiators are interested in the long-term perspective of working in the selected area, they should implement the project in accordance with environmental standards and take into account the environmental requirements of the local population in the area. Then the suspension of the activity of new projects due to non-fulfillment of environmental requirements will be prevented, because the legislation provides that the activity of objects that have a harmful effect on the environment can be limited or suspended according to the decision of specially authorized state bodies.

Based on the above comments, the following proposals were developed to improve the audit of environmental costs of new projects implemented in our country:

1. Development of special plans and model forms of the program, taking into account the audit of environmental costs, and their implementation.

As a result: accounting of environmental costs in the process of auditing costs related to the launch of new projects by auditing organizations will be improved, and the time spent on auditing will be reduced, as well as the effectiveness of audit results will be increased.

2. In any method of analytical operations during the audit of new projects, the costs of environmental protection measures that may arise during the implementation of the project and reserves for them are not taken into account. Therefore, when giving an audit opinion on the effectiveness of new projects, it is necessary to take into account the data used as a basis for calculating the indicators, the factors and risks affecting them, and the costs of environmental protection measures and the reserves for them in the analytical operations carried out to calculate the following:

- "normal" payback period (PP - Payback Period);
- discounted payback period (DPP - Discounted Payback Period);
- investment profitability coefficient (ROI — Return on Investment);
- coefficient of profitability index of investments (PI — Profitability Index);
- internal rate of return (IRR — Internal Rate of Return)
- net present value (NPV - Net Present Value).

As a result:

- first, it becomes possible to determine the real performance indicators of the new project;
- secondly, the auditor is prevented from giving a positive conclusion to a project that is ineffective, taking into account the costs of environmental protection measures and reserves for them;
- thirdly, it is avoided that the government chooses a project that is ineffective, taking into account the costs of environmental protection measures and reserves for them;
- fourthly, the investor is prevented from investing in a project that is ineffective, taking into account the costs of environmental protection measures and reserves for them.

Conclusion

The complexity of presenting the environmental consequences of the implementation of new projects in the form of money shows the importance of carefully evaluating the environmental costs and their probability of occurrence with professional judgment before the start of the project implementation. Due to the risk of accumulating negative environmental consequences towards the end of the project's life cycle, the importance of the project termination phase increases and requires a lot of attention. In this regard, as a result of the audit conducted to assess the economic efficiency of new projects, taking into account the environmental costs, the following will be achieved as a result of the organization and improvement proposals on the basis of a special plan and program:

1. On the basis of a special plan and program developed for the audit of costs related to the launch of new projects, the audit of environmental costs of new projects will be improved, and the time spent on conducting audits will be reduced, as well as the effectiveness of audit results will be increased.

2. Performance indicators of new projects ("Normal" payback period (PP - Payback Period), discounted payback period (DPP - Discounted Payback Period), return on investment (ROI), return on investment (PI) — Profitability Index), internal rate of return (IRR — Internal Rate of Return), net present value (NPV — Net Present Value)) as a result of providing an audit opinion by analyzing the environmental costs, as well as the formation of reserves for them it becomes possible to determine efficiency indicators, and the auditor is prevented from giving a positive conclusion to an ineffective project, taking into account the costs of environmental protection measures, as well as reserves for them, the directorate considers the costs of environmental protection measures, as well as selection of an inefficient project taking into account reserves is avoided, costs of environmental protection measures by the investor, as well as investments into an inefficient project taking into account reserves are avoided.

References:

1. (n.d.). *Decree of the President of the Republic of Uzbekistan dated 07.06.2022 No. PF-165 "On approval of the innovative development strategy of the Republic of Uzbekistan in 2022 - 2026".* Retrieved from https://lex.uz/docs/6102462
2. (n.d.). *Order of the Minister of Finance of the Republic of Uzbekistan on recognition of the text of international financial reporting standards and explanations for use in the territory of the Republic of Uzbekistan, registered on 09.12.2022, list number 3400.* Retrieved from https://lex.uz/docs/6312360
3. (n.d.). *Decree of the President of the Republic of Uzbekistan dated September 8, 2022 No. PF-215 "On measures to improve the activities of the direct investment fund of the Republic of Uzbekistan".* Retrieved from https://lex.uz/docs/6185471
4. (n.d.). *Decree of the President of the Republic of Uzbekistan dated 30.10.2019 No. PF-5863 "On approval of the concept of environmental protection of the Republic of Uzbekistan until 2030".* Retrieved from https://lex.uz/uz/docs/4574008
5. (n.d.). *Law of the Republic of Uzbekistan. About accounting. No. ORQ-404, 13.04.2016.*
6. (n.d.). *Law of the Republic of Uzbekistan. About investments and investment activities. N O'RQ-598, 25.12.2019.*
7. Bocharov, V.V. (2000). *Investment management: Textbook.* manual. (p.160). St. Petersburg: Peter.
8. Savchuk, V. P. (2012). *Analysis and development of investment projects:* Textbook. manual for universities / V. P. Savchuk, S. I. Prilipko, E. G. Velichko. Absolut-V, 302 p.
9. Jia, X., Cui, Y., Patro, R., Venkatachalam, S., Kanday, R., & Turayevich, J. (2023). Application of fractional-order nonlinear equations in coordinated control of multi-agent systems. *Nonlinear Engineering*, 12(1), 20220335. https://doi.org/10.1515/nleng-2022-0335
10. (2012). *WAN Chun, Economy School, Jiangxi University of Finance and Economics, P.R.China, «Financial Evaluation of Investment Projects from the Angle of Ecology».*
11. Birman, G., & Schmidt, S. (2002). *Economic analysis of investment projects.* Per. from English ed. LP White. - M: Banks and exchanges, UNITY.
12. Chuprikova, Z.V. (2016). *Audit of investment projects. Tutorial*. (p.122). M.: MIIT.
13. Babaev, Yu. A., & Petrov, A. M. (2018). *International Financial Reporting Standards (IFRS).* (p.398). M.: University textbook: INFRA-M.
14. Melnik, M.V. (2020). *Analysis of the financial and economic activities of the enterprise. Tutorial*. (p.208). M.:FORUM: INFRA-M.
15. Tuychiev, A., Koziev, I., Avlokulov, A., Sherimbetov, I., & Avazov, I. (2019). *Audit.* Textbook. (p.530). T.: "Economy-Finance".
16. Rakhimov, M. Yu., et al. (2021). *Economic analysis.* Textbook. (p.492). T.: Nihol-Print.
17. Kuziev, I.N., Hamdamov, B.K., Avazov, I.R., & Ochilav, F.Sh. (2021). *Auditing halkaro standardlari. Electron darslick.* –T.: TMI.
18. Trofimova, L. B. (2019). *International financial reporting standards: textbook and workshop for bachelor's, specialist and master's degrees.* — 5th ed., rev. and additional. (p.242). M.: Yurayt Publishing House.
19. Sheremet, A. D. (2021). *Analysis and diagnostics of financial and economic activities of an enterprise.* Textbook. (p.374). M.:INFRA-M.
20. (n.d.). *national database of legislative information of the Republic of Uzbekistan* Retrieved from https://www.lex.uz
21. Turayevich, J. I., & Akmal o'g'li, S. M. (2023). Investitsion loyihalarni moliyalashtirishda tiklanish va taraqqiyot jamg'armasining o'rni. *Pedagogs jurnali*, 35(4), 147-157.
22. Jumaniyazov, I. T. (2021). The Progressive Foreign Experiments in the Activity of Sovereign Wealth Funds. *Annals of the Romanian Society for Cell Biology*, 109-116.
23. Jumaniyozov, I. (2018). Impact of Development Finance Institutions on Economic Growth: Implications for Reconstruction and Development Fund of Uzbekistan. *International Journal of Management Science and Business Administration*, 4(2), 84-88.
24. Jumaniyozov, I. (2020). Issues of ensuring the transparency of sovereign wealth funds. *International Finance and Accounting*, 2020 (5), 1.
25. Jumaniyazov, I. (2020). Foreign experience in the activities of sovereign funds. *International Finance and Accounting*, 2020(2), 1.
26. Jumaniyazov, I. T. (2021). Transparency Is A Key Indicator Of The Activity Of Sovereign Wealth Funds. *The American Journal of Management and Economics Innovations*, 3(05), 30-37.

SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)
Year: 2024 **Issue:** 02 **Volume:** 130
Published: 08.02.2024 **http://T-Science.org**

Issue Article

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DOPPLEROGRAPHIC CHANGES IN PORTAL HEMODYNAMICS IN PATIENTS WITH COMPENSATED AND DECOMPENSATED CIRRHOSIS OF THE LIVER

Abstract: *The work studied hemodynamics in the vessels of the portal system in patients with compensated and decompensated cirrhosis of the liver. It has been shown that the use of ultrasound dopplerography of portal system vessels makes it possible to diagnose cirrhosis of the liver in the early, compensated stages, which can help in determining further tactics of treatment and prevention of complications.*

Key words: *cirrhosis of the liver, pulse wave ultrasound dopplerography, portal hypertension, common hepatic artery, splenic artery, portal vein, splenic vein.*

Language: *Russian*

Citation: Rakhimova, Z. R., Khodzhakuliev, B. G., & Elyasov, M. A. (2024). Dopplerographic changes in portal hemodynamics in patients with compensated and decompensated cirrhosis of the liver. *ISJ Theoretical & Applied Science, 02 (130)*, 41-47.

Soi: http://s-o-i.org/1.1/TAS-02-130-6 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.02.130.6

Scopus ASCC: *2721.*

ДОППЛЕРОГРАФИЧЕСКИЕ ИЗМЕНЕНИЯ ПОРТАЛЬНОЙ ГЕМОДИНАМИКИ У БОЛЬНЫХ КОМПЕНСИРОВАННЫМ И ДЕКОМПЕНСИРОВАННЫМ ЦИРРОЗОМ ПЕЧЕНИ

Аннотация: *В работе изучена гемодинамика в сосудах портальной системы у больных компенсированным и декомпенсированным циррозом печени. Показано, что применение ультразвуковой допплерографии сосудов портальной системы позволяет диагностировать цирроз печени на ранних, компенсированных стадиях, что может помочь в определении дальнейшей тактики лечения и профилактики осложнений.*

Ключевые слова: *цирроз печени, импульсноволновая ультразвуковая допплерография, портальная гипертензия, общая печеночная артерия, селезеночная артерия, портальная вена, селезеночная вена.*

Введение

Хронические заболевания печени представляют на сегодняшний день не только медицинскую, но и социально - экономическую проблему, являясь одной из частых причин, приводящих к временной нетрудоспособности,

инвалидности и летальности. Процессы фиброгенеза, развивающиеся вследствии различных заболеваний печени, приводят к структурным изменениям паренхимы печени, ее цирротической трансформации и синдрому ПГ [2]. Большой процент осложнений у пациентов с циррозом печени связан с синдромом портальной гипертензии. Под портальной гипертензией (ПГ) понимают повышение давления в воротной вене (ВВ) выше 10-12 мм рт. ст. Наиболее частыми причинами синдрома портальной гипертензии у детей и взрослых до 30 лет считаются цирроз печени, синдром Бадд-Киари, болезнь Вильсона-Коновалова, врожденный печеночный фиброз, тромбоз внепеченочной части воротной вены, билиарная атрезия [5]. Развитие синдрома портальной гипертензии связано с декомпенсацией болезни и характеризуется появлением таких симптомов, как асцит, спленомегалия, печеночная энцефалопатия, варикозное расширение вен пищевода и желудка, прямой кишки и др. На доцирротической стадии гипертензия в системе воротной вены выявляется в 50% наблюдений и достигает 90% при сформировавшемся циррозе [1]. Ранняя диагностика ПГ очень важна, так как во многом предопределяет дальнейшую тактику лечения пациентов (включая хирургическое).

В последние годы придают большое значение косвенным признакам портальной гипертензии, которые легко определить не инвазивным и доступным методом ультразвуковой допплерографии сосудов брюшной полости, при проведении которой акцент делается на исследование сосудов портальной системы. Ультразвуковыми признаками портальной гипертензии считаются увеличение диаметра ВВ (не постоянный признак), асцит, реканализация пупочной вены, спленомегалия, развитие коллатералей [4,7,8]. Некоторые авторы разделяют условные (спленомегалия, асцит, расширение вен воротной системы, снижение скорости воротного кровотока (Vвв <15 см/сек), повышение индекса резистентности (IR) в печеночной артерии (IRопа ≥ 0,74), измененный кровоток в печеночных венах) и безусловные (неровность контура печени, извитой ход внутрипеченочных сосудов, кровоток в параумбиликальной вене (ПУВ) и обратное, гепатофугальное, направление воротного кровотока [8]. Ряд авторов большое значение придают изменениям селезеночной гемодинамики, и считают, что они проявляются уже на стадии гепатита и могут быть ранними проявлениями ПГ, но следует отметить, что число работ посвященных исследованию гемодинамики селезенки невелико [5].

Цель работы

Изучить кровоток в сосудах портальной системы у больных компенсированным и декомпенсированным циррозом печени.

Материалы и методы

Было обследовано всего 60 больных циррозом печени (ЦП) в возрасте от 16 до 66 лет, средний возраст–48±4,8 26 мужчин и 34 женщины, которые были поделены на 3 группы. В I группу вошли 20 (33,4%) больных с компенсированным ЦП - “А” класс по Child-Pugh, во II группу 24 (40%) больных с субкомпенсированным ЦП - “В” класс по Child-Pugh больных и в III группу вошли 16 (26,6%) больных с декомпенсированный ЦП – “С” класс по Child-Pugh. Контрольную группу (КГ) составили 20 практически здоровых лиц без патологии печени от 19 до 50 лет, средний возраст составил- 31±2,3 года, 8 мужчин и 12 женщин. В группе больных ЦП длительность заболевания составила от 1 до 5 лет. По этиологии больные распределились следующим образом: вирусной В этиологии ЦП- 24 (40%), вирусной С этиологии ЦП- 23 (38,3%) больных, аутоиммунный ЦП у 2 (3,3%) больных, алкогольный цирроз печени у 8 (13,3%) больных. Клинически у больных с ЦП с различной частотой определялись печеночные знаки (пальмарная эритема, телеангиэктазии, желтуха, меланодермия, явления холестаза, отечно-асцитический синдром).

Для постановки диагноза была использована классификация хронических диффузных заболеваний печени (ХДЗП), принятая на Всемирном конгрессе гастроэнтерологов в Лос-Анджелесе в 1994 году. Клинический диагноз ставился с учетом анамнестических сведений и результатов комплексного клинико-биохимического, вирусологического, иммунологического и инструментального обследований. Для оценки функционального состояния печени определяли уровень общего билирубина и его фракции, альбумина, протромбинового индекса, активности АсАТ, АлАТ общепринятыми методами. Степень активности процесса определялась по активности ферментов (АсАТ, АлАТ), стадия процесса определялась на основании результатов эластометрии, проводимой на аппарате Fibroscan фирмы Eho-S (Франция) по шкале METAVIR. Наличие варикозно расширенных вен пищевода и гипертензионной гастропатии определялось методом ФГДС. Ультразвуковое исследование (УЗИ) проводилось на аппарате Siemens (Германия), работающем в реальном масштабе времени с линейным датчиком частотой 3,5 - 5 МГц. Перед обследованием больным предварительно назначали симетикон - 240 мг/сутки. При ультразвуковом исследовании

обращалось внимание на контуры, размеры, структуру и эхогенность органов. Для оценки печеночного и селезеночного кровотока проводилась импульсноволновая допплерография портальной (ПВ) и селезеночной вен (СВ), где измерялся диаметр сосуда и в автоматическом режиме определялись следующие параметры - максимальная линейная скорость кровотока (Vmax), минимальная скорость кровотока (Vmin), усредненная во времени максимальная скорость (TAMX). Объемная скорость кровотока (Vvol) вычислялась по формуле

$$V_{vol} = \frac{\pi \times D^2}{4} \times \frac{TAMX}{1{,}6} \times 60 .$$

Также изучался кровоток в общей печеночной (ОПА) и селезеночной артериях (СА), где определялись следующие параметры: диаметр сосуда (D,mm), максимальная скорость кровотока (Vmax), минимальная скорость кровотока (Vmin), индекс резистентности (IR), пульсационный индекс (PI), систоло-диастолический индекс (S/D), и усредненная во времени скорость (TAMX).

Статистическая обработка материала проводилась с помощью программ Microsoft Excel 7 и STATISTICA 6.0 (StatSoft, США). Данные представлены в виде M±m, где M – среднее значение величины, m – ее стандартная ошибка.

Результаты и обсуждение

У больных ЦП при ультразвуковом исследовании контуры печени были неровные, с очагами повышенной (фиброзные очаги) и сниженной эхогенности (узлы регенерации), сосудистый рисунок полностью не прослеживался. Капсула печени во многих случаях была утолщена, местами прерывалась. Гепатомегалия была выявлена у 21 (35%) больных из 60, нормальные размеры печени у 18 (30%) больных и уменьшение размеров печени, атрофия наблюдалась у 21 (35%) больного. Наибольшие размеры печени–160×86 мм, наименьшие–76×36 мм. Спленомегалия была выявлена у 58 (96,6 %) больных. Самый большой размер селезенки составил 240×82 мм. Ультразвуковые изменения у пациентов ЦП в зависимости от компенсации болезни представлены в таблице №1.

Таблица 1. Ультразвуковые признаки в зависимости от стадии декомпенсации ЦП

Ультразвуковые признаки	А класс	В класс	С класс
Гепатомегалия	6	7	7
Нормальные размеры печени	12	4	2
Атрофия	2	13	6
Спленомегалия	18	24	16
Неровность контуров печени	9	22	16
Утолщение стенок желчного пузыря	11	24	16
Асцит	2	24	16
Анастомозы	1	20	16

При импульсноволновой допплерографии сосудов максимальная скорость в ПВ значительно уменьшилась во всех группах в сравнении с КГ: на 38,2 % у больных в I группе, на 41,4% во II группе и на 52,7% у больных III группы. С увеличением класса функциональной недостаточности уменьшалась и максимальная скорость. Если в I и II группах скорость существенно не отличалась между собой, то в III группе больных максимальная и минимальная скорости уменьшились на 2,0 ± 0,5 см/с и 1,1 ± 0,5 см/с соответственно (P<0,001) в сравнении с I группой. В СВ скоростные показатели как в группах, так и в сравнении с КГ между собой значимо не отличались.

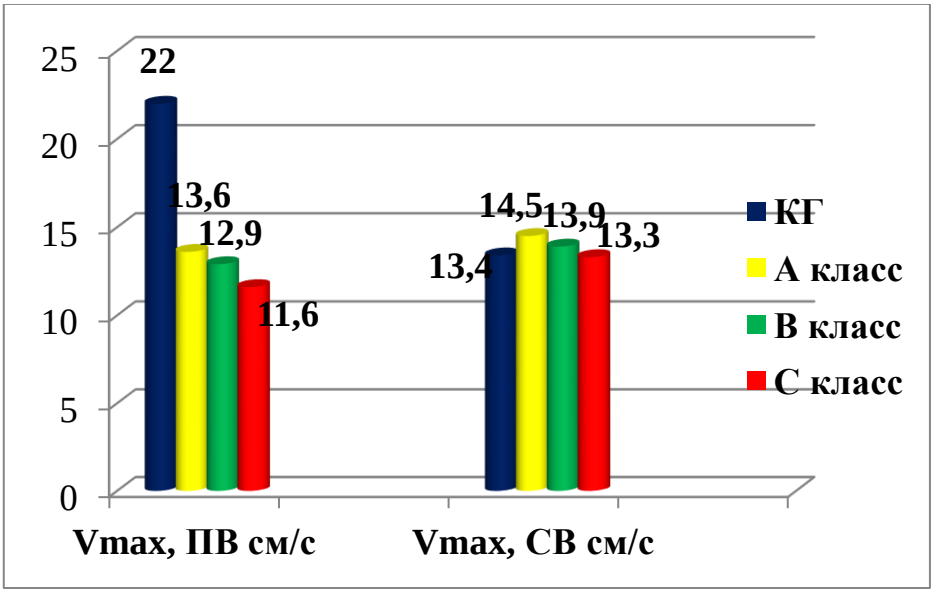

Рисунок 1. Изменения Vmax (см/с) в ПВ и СВ в зависимости от класса Child-Pugh.

В сравнении с КГ ТАМХ уменьшилась на 29,3% в I группе, на 32,3% во II группе и на 29,7% в III группе. Диаметр ПВ значимо увеличился в I группе больных ЦП - на 23%, во II и III группах больных значимых отличий в диаметре ВВ между группами больных и контрольной группой выявлено не было. Диаметр СВ увеличился во всех группах в сравнении с КГ: на 50% в I группе (класс А) и на 45,5% во II и III группах (классы В и С соответственно).

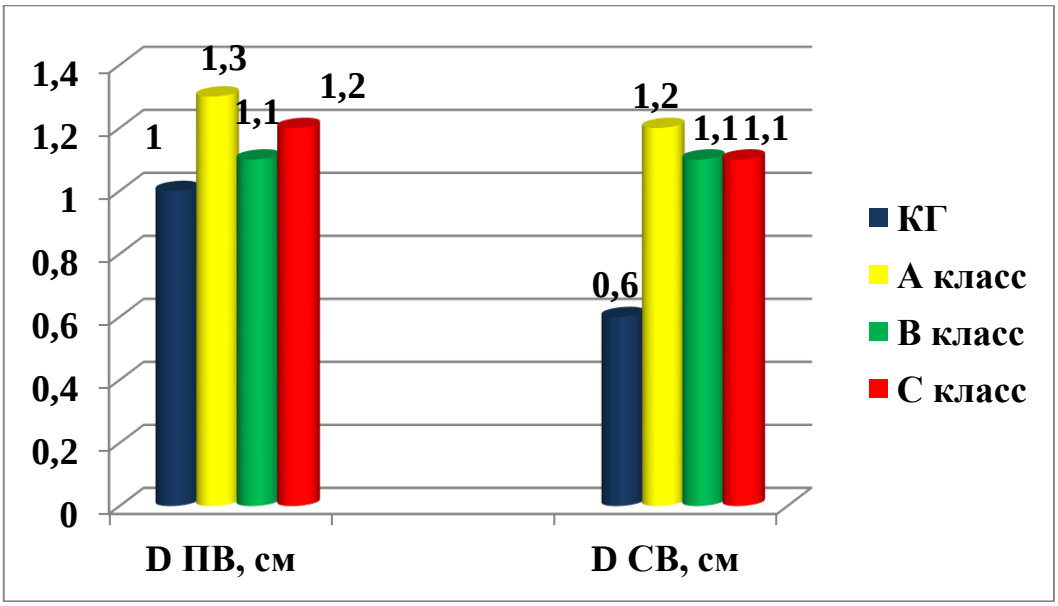

Рисунок 2. Изменения диаметра ПВ и СВ в зависимости от класса Child-Pugh.

Объемная скорость в ПВ увеличилась в I группе на 20,8% в сравнении с КГ, на 34% в сравнении со II группой и на 25,3% в сравнении с III группой пациентов. Наименьшая объемная скорость наблюдалась во II группе больных, что на 16,9% меньше чем КГ. В III группе объемная скорость уменьшилась на 5,7% в сравнении с КГ.

Наблюдалось так же увеличение объемного кровотока в СВ, самый большой объемный кровоток отмечался у больных в I группе, что на 81,8 % больше чем в КГ. У больных II группы объемный кровоток увеличился на 74,1% в сравнении с КГ и наконец у больных в III группе увеличилась на 61,6% в сравнении с КГ.

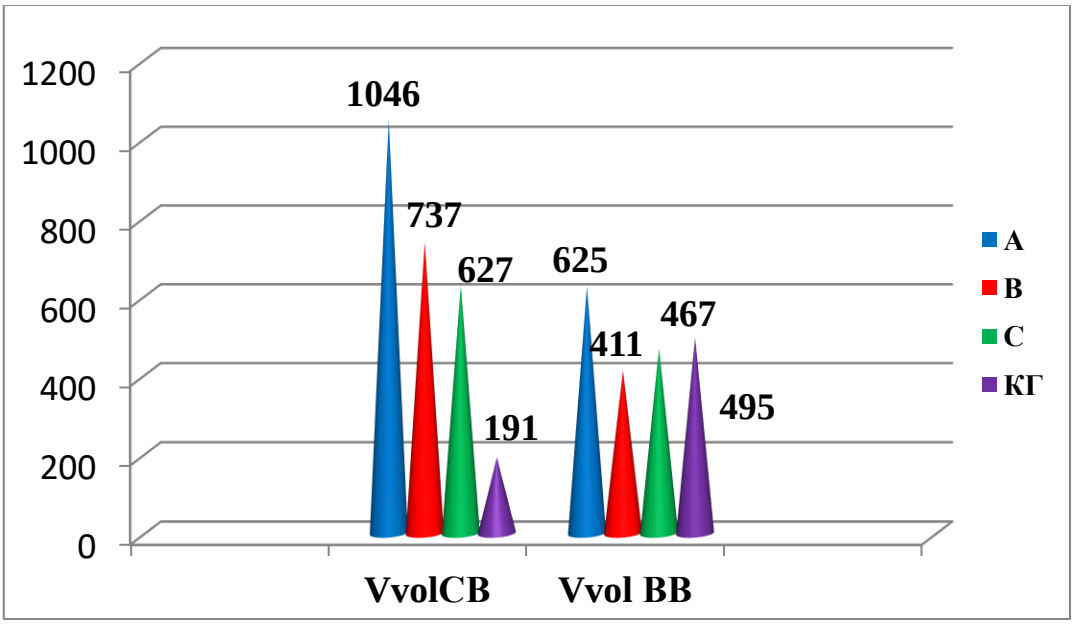

Рисунок 3. Изменения Vvol (мл/мин) в ПВ и СВ в зависимости от класса Child-Pugh.

Изменения гемодинамики в портальной и селезеночной венах представлены в таблице № 2.

Таблица № 2. Изменения гемодинамики в ВВ и СВ в классах A, B, C по Child-Pugh

Показатели	I (Класс А)	II (Класс В)	III (Класс С)	КГ
Vmax **пв**,sm/s	13,6 ± 1,2*	12,9 ± 0,5**	11,6 ± 0,5***	22,0 ± 0,7
Vmin **пв**,sm/s	9,6 ± 0,9*	9,3 ± 0,4**	8,5 ± 0,4***	12,5 ± 0,8
D **пв**, sm	1,3 ± 0,4	1,1 ± 0,5	1,2 ± 0,06***	1,0 ± 0,3
Vvol **пв**,ml/min	625 ± 22*	411 ± 33**	467 ± 74***	495 ± 2,5
TAMX **пв**, sm/s	11,1 ± 1,1*	10,7 ± 1,4**	9,9 ± 0,9***	15,8 ± 1,0
Vmax **св**,sm/s	23,5 ± 2,4*	21,2 ± 1,3	22,5 ± 1,7***	20,2 ± 1,5
Vmin **св**,sm/s	14,5 ± 1,4	13,9 ± 1,1	13,3 ± 0,6	13,4 ± 0,6
D **св**, sm	1,2 ± 0,08*	1,1 ± 0,03**	1,1 ± 0,04***	0,6 ± 0,2
Vvol **св**,ml/min	1046 ± 256*	737 ± 129**	627 ± 38,3***	191± 19,7
TAMX **св**, sm/s	18,7 ± 1,8*	15,4 ± 1,3	17,2 ± 1,1	16,8 ± 1,01

(P < 0,001) - достоверность между классом А и КГ;*
*(P < 0,001)** - достоверность между классом В и КГ;*
*(P < 0,001)*** - достоверность между классом С и КГ.*

В артериях портальной системы так же были выявлены изменения кровотока. Так в ОПА отмечалось увеличение максимальной скорости во всех группах в сравнении с КГ. Больше всего скоростные показатели увеличились в I группе больных (класс А): максимальная скорость увеличилась на 31%. Во II и III группах пациентов (класс В и С соответственно) максимальная скорость существенно не отличалась друг от друга и выросла на 19,5% в сравнении с КГ. Минимальная скорость увеличилась значимо в I группе больных - на 30%, во II группе практически не изменилась, а в III группе снизилась на 15,1%. TAMX так же увеличилась только в I группе больных на 21,7%. В других группах особых отличий не наблюдалось. Если скоростные показатели имели тенденцию к уменьшению с возрастанием декомпенсации ЦП, то IR увеличивался с возрастанием класса по Child-Pugh: на 13%, 20% и 21% соответственно в I, II и III группах. PI практически не изменился во всех сравниваемых группах в сравнении с КГ и существенно не отличался между собой. Что касается S/D отношения и диаметра сосуда, то кардинальных отличий как между сравниваемыми группами, так и в сравнении с КТ выявлено не было. В СА, так же наблюдалось увеличение максимальной скорости в I, II и III группах в сравнении с контролем: на 35,7%, 20,6%, 33,2% соответственно. Причем, наибольшей она была в I группе больных, а наименьшей во II группе больных. Что касается минимальной и усредненной скоростей, то больше всего показатели увеличились опять же в I группе больных на 29,1% и 47,2% соответственно. Во II и III группах больных эти параметры существенно не отличались от КГ. IR и PI увеличился в I, II, III группах на 14% и 24%; 17% и 21,5%; 22% и 30,3% соответственно в сравнении с КГ. Диаметр сосуда достоверно увеличился в I и II группах больных (P<0,001). Изменения кровотока в ОПА и СА показано в таблице № 3.

Таблица 3. Изменения гемодинамики в ОПА и СА в классах А, В, С по Child-Pugh.

Показатели	**I (Класс А)**	**II (Класс В)**	**III (Класс С)**	**КГ**
Vmax**опа**,sm/s	82,7 ± 10,9*	70,5 ± 6,4**	71,3 ± 7,9***	57,4 ± 1,5
Vmin**опа**,sm/s	34,6 ± 7,8*	26,4 ± 3,7	21,5 ± 3,3	25,3 ± 3,8
IR**опа**	0,73 ± 0,23*	0,80 ± 0,06**	0,81 ± 0,05***	0,64 ± 0,03
PI**опа**	1,7 ± 0,2	1,8 ± 0,3	1,9 ± 0,2	1,9 ± 1,7
S/D**опа**	3,1 ± 0,34	3,6 ± 0,41	3,7 ± 0,5	3,2 ± 0,3
D**опа**, sm	0,6 ± 0,03*	0,6 ± 0,03	0,6 ± 0,03	0,5 ± 0,02
TAMX, sm/s	39,3 ± 6,4*	32,7 ± 3,9	33,2 ± 4,0	30,8 ± 3,5
Vmin**са**,sm/s	29,9 ± 7,4*	22,9 ± 2,2	22,3 ± 1,9	21,2 ± 2,3
IR**са**	0,66± 0,04*	0,68± 0,03**	0,73 ±0,02***	0,57 ±0,02
PI**са**	1,3±1,2	1,26 ±0,08**	1,42 ± 0,2***	0,99 ± 0,2
S/D**са**	3,2 ± 0,4*	3,1 ± 0,2**	3,4 ± 0,7***	2,5 ± 0,18
D**са**, sm	0,7 ± 0,06*	0,6 ±0,03	0,7 ± 0,04***	0,5± 0,03
TAMX, sm/s	40,1 ± 9,3*	30,9 ± 2,0	31,7 ± 2,5	29,4±2,2

(P < 0,001) - достоверность между классом А и КГ;*
*(P < 0,001)** - достоверность между классом В и КГ;*
*(P < 0,001)*** - достоверность между классом С и КГ.*

Выводы

В результате проведенных исследований было выявлено, что изменения портальной гемодинамики выявляются уже на стадии *A* по Child-Pugh и выражаются уменьшением скорости кровотока в ПВ увеличением диаметра и объемного кровотока в СВ. Максимальная скорость в ПВ прогрессивно снижается с увеличением стадии декомпенсации ЦП. Увеличение диаметра ПВ не является постоянным признаком ЦП и портальной гипертензии, с увеличением количества функционирующих анастомозов диаметр вены может уменьшаться до нормальных размеров, а увеличение диаметра и объемного кровотока в СВ выявляются еще на стадии компенсации ЦП и сохраняются независимо от стадии декомпенсации. Уменьшение диаметра СВ и объемного кровотока в ней в классах В и С по Child-Pugh можно объяснить сбросом крови в систему коллатералей, которых значительно больше при декомпенсированном циррозе печени. Увеличивается артериальная перфузия печени и периферическое сопротивление в сосудах, что выражается увеличением IR в ОПА и СА.

Таким образом, импульсноволновая допплерография сосудов портальной системы помогает выявить изменения печеночной гемодинамики еще на ранних стадиях, что дает возможность назначить своевременную, адекватную терапию и избежать многих осложнений портальной гипертензии.

References:

1. Kotiv, B.N., et al. (2013). Primenenie terlipressina pri krovotecheniyah iz varikozno-rasshirennyh ven pishchevoda u bol'nyh cirrozom pecheni s sindromom portal'noj gipertenzii. *RZHGGK*. № 5, pp.57-60.
2. Mardar'eva, S.V. (2006). *Portal'naya gipertenzionnaya gastropatiya kak proyavlenie portal'noj gipertenzii pri cirroze pecheni (kliniko-laboratornye i instrumental'nye korrelyacii, osobennosti terapii).* Avtoref.diss.dokt.med.nauk. Moskva.
3. Mit'kov, V.V., & Bryuhoveckij, Yu.A. (2003). *Ul'trazvukovaya diagnostika zabolevanij pecheni/* Prakticheskoe rukovodstvo po ul'trazvukovoj diagnostike. Obshchaya ul'trazvukovaya diagnostika/ pod red. Mit'kova V.V. (pp.39-133). M.: Izdatel'skij dom «Vidar» - M.
4. Mit'kov, V.V., et al. (2000). Ocenka portal'nogo krovotoka pri cirroze pecheni. *Ul'trazvukovaya diagnostika*. № 4, pp.10-17.
5. Raevneva, T.G. (2000). Narushenie vnutripechenochnoj gemodinamiki pri ostryh hronicheskih gepatitah, vyyavlyaemye s pomoshch'yu ul'trazvukovoj dopplerometrii. *Novosti luchevoj diagnostiki*. № 2, pp.29-31.
6. Ryhtik, P.I., et al. (2008). Diagnosticheskoe znachenie vremeni akseleracii v selezenochnoj arterii dlya ocenki portal'noj gipertenzii. *Medicinskij al'manah/ specvypusk*, pp. 168-170
7. Chernousov, A., et al. (2011). UZI v diagnostike cirroza pecheni. *Vrach*, .№ 6, pp.82-85.
8. Shipov, O.Yu. (2002). *Diagnostika portal'noj gipertenzii pri ul'trazvukovoj angiografii pecheni:* Avtoref. diss. kand.med.nauk. Moskva.

Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 13.02.2024 **http://T-Science.org**

Issue Article

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ECOSYSTEM STUDIES AND REMEDIATION OPPORTUNITIES

Abstract: *In Georgia, as well as in the South Caucasus region as a whole, it is an urgent necessity to conduct environmental and eco-expert studies according to threats and challengesusing respective utilizing and neutralizing systems. Agricultural soils of the Kakheti region were studied, which implies the classification of soil structure, mechanical division of organic matter by its percentage content, investigation of the cation exchange capacity (CEC), mobile, soluble forms of heavy metals and nutrients. A liquid stimulator was used, which ensured the binding-accumulation process of excessive heavy metals in the soil up to the maximum allowable contamination (MAC). The soils of the Kakheti region were found to be moderately and heavily clayey, and black soil types with the medium and high fertility growth rate. Their excessive content of calcium, iron, sodium, nitrogen and phosphorus can be supposedly explained by the overuse of chemical fertilizers. It is established that mobile-soluble forms of heavy metals (lead, copper, zinc) in the soil exceed MAC. Research work was carried out using such physic-chemical research methods as atomic-absorption, X-ray fluorescence, the EPA TCLP and WET test standards, and quantitative-chemical analysis.*

Key words: *ecotoxicology, heavy metals, TLV, research methods, remediation, pesticide, leaching.*

Language: *English*

Citation: Gigauri, R., Khvichia, L., & Rusia, M. (2024). Ecosystem studies and remediation opportunities. *ISJ Theoretical & Applied Science, 02 (130),* 48-51.

Soi: http://s-o-i.org/1.1/TAS-02-130-7 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.7

Scopus ASCC: *1600.*

Introduction

The modern scale and pace of anthropogenic changes in nature can initiate irreversible processes in the environment, which can be avoided only if we know all the processes taking place in ecological systems.In addition to ecological monitoring, ecological expertise and ecological modeling are used in the provision of environmental systems. Ecological expertise is a special type of ecological research and is aimed at assessing the impact of industrial-economic and other types of facilities on the environment, natural resources, and human health. Eco-expertise, as a systematic study of the problem, is equal to 1 percent of the export value, but these costs are incomparably small compared to the costs that the country bears to eliminate the consequences of wrong decisions, as well as those that threaten people's lives and health [1].

Experimental part

The basis of our research was a comprehensive survey of the agricultural soil of one territory of Georgia, the Kakheti region, in order to determine what threats and challenges faced thisterritory distinguished by amazingly abundant harvests.38 percent of Georgia's agricultural land is in Kakheti, where arable lands and pastures occupy the largest area. Climate: generally, dry subtropical. Soils: pH=6-7; mostly carbonated humus with moderate, amorphous iron content; salting and carbonation are also characteristic of them. Harvest: cereals – maize/corn; vegetables –potatoes, cucumbers, tomatoes; fruit – grapes, strawberries. Up to 20 soil samples on agricultural land plots of different purposes of the private sector have been studied. It is known that the ratio of air and water creates the structure of the soil. Degraded humus indicates a hardened layer of formed in the upper part of humic substances (HS), a violation of the soil structure. If the water permeability, moisture, aeration of the soil is disturbed, the soil is found exhausted (C: N=25-30:1).

As a result of studying the soils of Kakheti, the classification of the soil structure (acidity, total organic matter, humus, density, type, porosity, moisture content) has been established. By the composition, the soils of Kakheti region represent moderately and heavily clayey, and black soil types with the medium and high fertility growth rate, without the risk of degradation. Organic substances in the soil were determined by mechanical division - percentage contents of sand, silt, clay, silt, which is one of the components for determining the soil type.The study of cation exchange capacity (CEC) in the soil plays a very important role. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants.

The soils of Kakheti have also been found to contain excess calcium, iron, and sodium. An excess of nitrogen and phosphorus was also revealed during the NPK study [2; 3]. In terms of agro-ecotoxicology, the EPA TCLP and WET test methods were used, which means the processing of mobile-soluble forms of heavy metals in the soil, for their further instrumental determination.As a result of the research, the content of heavy metals exceeding MAC (lead - 3 times, copper - 0.6 times, zinc - 1.5 times) has been determined. Based on the liquid stimulator produced by us, the content of heavy metals can be reduced to MAC, which excludes the risk of their transfer from soil to the green cover and plant products.

Below are the results of the soil sample analysis in the form of a table.

Table 1. Results of analysis of agricultural soils

Kakheti Region	**Classification of soil structure**								
	Overal organic matter,%	**Hunus, %**	**Density, cm^3**	**Soil type**	**Porosity, %**	**Water-holding**			
	10,12	**4,70**	**1,5-2,0**	**Moderately & heavily clayey**	**45-50**	**60**			
	Percentage of organic matter in soil								
	Sand %		**Fiane sand %**		**Clay %**		**Silt %**		
	9,9		**10,10**		**61,5**		**18,12**		
	CEC								
	Ca mg/100	**Mg mg/100**	**Na mg/100**	**Total:**	**From the sum of adsorbed bases, %**				
					Ca	**Mg**	**Na**		
	15,7	**7,0**	**1,35**	**24,05**	**66,0**	**33,0**	**5,6**		
	Content of nutrients in the soil								
	pH	**N mg/100**	**P_2O_5 mg/100**	**K_20 mg/100**	**Fe %**	**S %**			
	6.5	**6**	**5**	**26**	**6**	**0.02**			
	Heavy metalsmg/kg								
	Pb	**Cd**	**Cu**	**Zn**	**Mn**	**Ni**	**Ti**	**As**	**Sb**
	0.6	**Trace**	**40**	**4**	**0,01**	**0,08**	**0,05**	**----**	**----**

The presented table clearly shows that the soils of the Kakheti region of Georgia are quite fertile and not endangered with degradation. The irregularities found in the soils are subject for discussion and can be easily corrected [4].

Results and discussion

As a result of our research, a complete picture of agricultural soils in the Kakheti region is presented.As a result of soil structure classification, the soil type has been found to be medium and heavy clayey.

Given that a soil's CEC is being determined by the clay and organic matter present, it implies the soil buffering - the volume fraction of organic substances with the CEC. For example, nitrogen (NH_4-N), K, Ca, and Mg, stick to negatively charged particles, as a result of which the soil becomes a reservoir of plant nutrients. The soil is rich in calcium and sodium. If we consider the content of nutrients, the contents of NPK, Fe, S twice exceed MAC, which could be explained by the overuse of chemical fertilizers [5] (Table 1). In terms of agro-ecotoxicology, the EPA TCLP and WET test methods were used, which implies the processing of mobile-soluble forms of heavy metals in the soil, for their further determination, using atomic absorption spectrophotometer (AAS).

According to TCLP, a 1:20 buffer was added to a 20 g soil sample under constant stirring using a magnetic stirrer for 24 hours at a temperature of 30 ^{0}C. According to the WET test method, a buffer solution in the ratio of 1:10 was added to the 20g soil sample under the same conditions for only 48 hrs.The mobile, soluble forms of heavy metals in the soil exceeded the MAC value (Pb – 3 times, Cu – 6 times, Zn - 1.5 times). Most likely the excess Pb should have been caused by the anti-hail device containing a lead-containing preparation. As for excessive content of Cu, it should have been introduced into the soil as a Bordeaux mixture pesticide.

The dynamics of accumulation of heavy metals in the soil is presented below (Fig. 1).

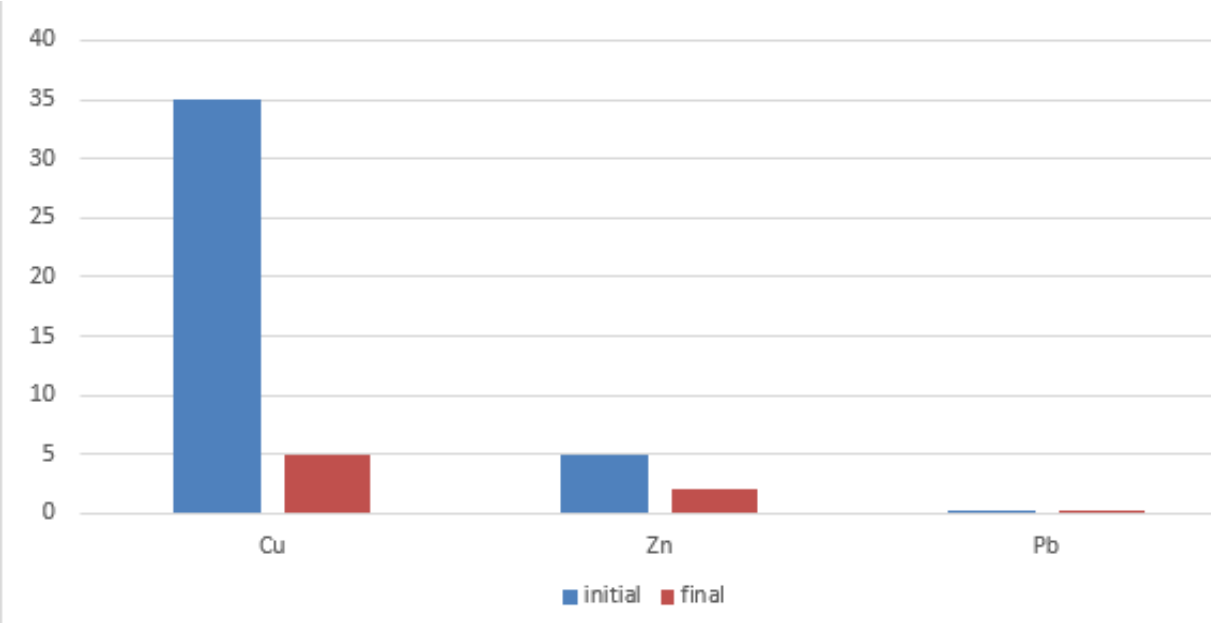

Figure 1. Dynamics of accumulation of mobile, soluble forms of heavy metals using stimulator in soil

If the mobile, soluble forms of toxic heavy metals exceed 1%, in this case phytoremediation can be carried out [6].

Conclusions

A complete survey of agricultural soils in the Kakheti region of Georgia has been carried out. Up to 20 soil samples were taken on land plots of different purposes, in A 0-20 horizontal and B 0-40 vertical directions.The classification of the soil structure has been studied, which implies the determination of pH, total organic matter, humus, density, soil type, porosity and moisture content. Organic substance sand their mechanical division, percentage contents (sand, fine sand, clay, and silt) have been studied. For a complete study of the soil, we considered it necessary to determine the exchange capacity (CEC) in the soil, as a result of which the soil becomes a reservoir of nutrients for plants. In terms of agro-ecotoxicology, mobile, soluble forms of heavy metals in the soil have been studied, using the state-of-the-art EPA TCLP (Toxicity Characteristic Leaching Procedure) and WET (Wet Extraction Test) test methods. The process of accumulation of toxic heavy metals under the action of a liquid stimulator manufactured by us has been studied. In our case, lead, copper, and zinc exceeded the MAC value. The soils of the Kakheti region were found to be moderately and heavily clayey, and black soil types with the medium and high fertility growth rate. The content of calcium, iron, sodium, nitrogen and phosphorus in them exceeds 1.2-2 times the MAC value, which is a result of the overuse of chemical fertilizers. The content of movable, soluble heavy metals has been found to exceed the MAC value: Cu – 6 times, Pb – 3 times, Zn – 1.5 times (Table 1). Based on the liquid stimulator produced by us, the content of these three metals can be reduced to MAC, which excludes the risk of their transfer from soil to the green cover and plant products. If the content of a

toxic heavy metal in the soil exceed 1%, the soil can be subject to phytoremediation.The Chinese ladder brake fern (*Pteris vittata)*is the best in this direction. For example, in an arsenic residue study, the fern absorbed 2% of the soluble form of arsenic.

References:

1. Gigauri, R., & Khvichia, L. (2022). Study of fill-up soils of the industrial regions of Georgia (Bolnisi-Kazreti). *European Academy of Sciences and Research*, vol. XXXIX (pp.22-29) Hamburg, Germany ISSN 2789-1968. Online ISSN2789-195X.
2. Arinushkina, E.V. (2013). *Manual on Chemical Analysis of Soil*. Moscow State University.
3. Fomin, G. S., & Fomin, A. G. (2001-2015). *Soil Quality Control and Ecological Safety According to International Standards.* ISBN 5-700631-06-0 (ISO).
4. (2012). *EPA test method 1111- TCLP Toxicity Characteristic Leaching Procedure*.
5. Urushadze, T. (2014). Genetic Peculiarities of the Black Soils of Georgia. *Annals of Agrarian Science*, vol.12, no.2. (pp.29-34). ISSN 1512-1887.
6. Brostow, W., Gigauri, R., & Lekishvili, N. (2010). Separation of Natural Trivalent Oxides of Arsenic and Antimony. *Chemical Engineering Journal* №159. (pp. 24-26). USA. doi: 10.1016/j.cej.2010.02.016

Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
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SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 13.02.2024 **http://T-Science.org**

Issue Article

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ABOUT THE FEATURES OF SUSTAINABILITY AND RESILIENCE OF CITIES OF THE RUSSIAN ARCTIC

Abstract: *in the article, the authors consider it as the ability of urban systems to overcome natural or man-made crises as a concept that mutually complements the concept of sustainable development. In the Arctic, characterized by increased vulnerability of both natural and economic systems, the application of the concept of resilience is especially relevant. The article analyzes 19 quantitative indicators of 27 Arctic settlements of the Russian Federation according to the following subsystems: economic specialization, life support and utilities, socio-cultural, natural-ecological, administrative and managerial. The cluster analysis identified seven stable groups of cities that consistently demonstrate similarities with each other under various analysis options. Overcoming crises in city development requires the simultaneous fulfillment of the conditions of resilience in different subsystems of urban development: the weakness of any of these subsystems can lead to the collapse of the entire system as a whole, therefore assessing resilience requires an integrated approach.*

Russia declares ambitious plans for the development of its Arctic zone, but it is inevitably associated with environmental risks, for which the Russian Arctic is not always ready. These are climate change, pollution of sea waters with oil and chemical runoff, and degradation of ecosystems. The idea that plans for the development of the Arctic region and, first of all, the development of offshore deposits should be reconsidered taking into account environmental hazards, resonates not only among environmental organizations, but also among economists. The unfavorable economic and foreign policy environment is the right moment to do this.

Key words: *sustainable development, Arctic cities, socio-ecological systems, the Arctic, climate change, oil spills, international environmental cooperation.*

Language: *English*

Citation: Golubeva, O. A., Zemsky, G. A., Blagorodov, A. A., Prokhorov, V. T., & Volkova, G. Yu. (2024). About the features of sustainability and resilience of cities of the Russian arctic. *ISJ Theoretical & Applied Science, 02 (130),* 52-66.

Soi: http://s-o-i.org/1.1/TAS-02-130-8 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.8

Scopus ASCC*: 2000.*

Introduction

UDC 332.23:338.17.

The Arctic is a single physical-geographical region of the Earth adjacent to the North Pole and including the outskirts of the continents of Eurasia and North America, almost the entire Arctic Ocean with islands (except for the coastal islands of Norway), as well as adjacent parts of the Atlantic and Pacific oceans. The Arctic is considered the most undeveloped region on Earth, with an area of about 27 million km². The bulk of the world's mineral resources are hidden here: 13% of oil, 30% of the world's natural gas reserves. Therefore, as economists suggest, the Arctic will become the center of the world.

Due to the promising growth of the Arctic, developed countries of the world are interested in getting some share for their own economic benefit. What is this benefit? This benefit can be considered as a lot of minerals (38%), large territory (6%), ensuring strategic security (5%) and biological resources (5%). Interested countries are Russia, Canada, Greenland, USA, Iceland, Norway and others, since oil and gas are the main factor in replenishing the national energy reserve. All these countries have a stable and strong economic system. This work will consider the following scientific works, which will identify the relevance of investments in the Arctic: “The Arctic: nanotechnology, military-industrial complex, investments, national idea” by Yuri Fedorovich Lukin, “The Arctic as an object of geopolitical interests of non-Arctic states” by Oleg Nikolaevich Podpelkin , “Problems of development of the Russian Arctic shelf” by Ivan Panichkin, “Problems of the “Arctic” topic in Russian and foreign media: management aspect” by T.A. Kovrigina.

Based on the research conducted, it can be noted that in recent years, in the geopolitical context, the value of the Arctic, which is one of the most important foundations of Russia’s defense and economic power, has increased significantly. The leadership of our country regularly emphasizes that the development of the Arctic territories is associated with the solution of long-term problems of fundamental geopolitical importance.

I. Panichkin notes that active work on the development of the Arctic shelf in the USSR began in the early 1980s. Development prospects were associated primarily with the Pechora and Kara seas, which are aquatorial extensions of the Timan-Pechora and West Siberian oil and gas provinces. The first investments were made in the creation of a drilling fleet in the period 1983–1992. In the Barents, Pechora and Kara seas, 10 large fields were discovered. And since then, step by step, Russia has been participating in the development and exploration of the Arctic regions of the country. In this regard, certain problems have now arisen regarding the modern development of the Arctic region, about the technologies of the sixth technological order, the military-industrial complex, and investments. According to Yu.F. Lukin, the problems posed were formulated extremely broadly and did not receive proper coverage. Many questions remain open. But, nevertheless, in order to implement its Arctic policy, Russia must create an Arctic organization of the state, including special objects, organizations and institutions, Arctic formations and bodies, which, in accordance with the Constitution of the Russian Federation, federal laws and other legal acts of the Russian Federation, are intended to carry out implementation tasks Arctic policy of the state using modern methods and means, as well as their management bodies. In addition to Russia, in recent years there has been an increasing interest of Arctic and non-Arctic states in the resources contained in the Arctic, as well as in the Northern Sea Route. The growth of geopolitical interests of Asian countries in the Arctic contains several fundamental aspects, namely:

Firstly, this is the logistics potential of the NSR, which opens up due to melting ice and can reduce the cost of economic growth in Asian countries.

Secondly, this is the presence of natural and biological resources, the volumes of which cannot yet be adequately assessed, as well as the virtually completed formation of scientific and technological capabilities for their cost-effective exploitation.

The third aspect is the actual geostrategic significance of the Arctic as a new platform for the interaction of international factors, which is associated with the persistent demands of Asian states for admission to participate in Arctic organizations and associations, for example, in the Arctic Council.

Fourthly, for Asian countries that are building up their respective economic and intellectual potential, the Arctic is a testing ground for developing the principles and technologies that will be needed for their future development of the resources and spaces of Antarctica and the highlands.

Fifthly, and in connection with the last, it is of fundamental importance (especially for the Russian Federation) that political and legal methods and information technologies are being developed in the Arctic to justify the statuses of “terra and aqua nullius”, internationalization and ensuring access to

the resources available there without use of military means.

International relations in the Arctic are becoming a system-forming element of world geopolitics, defining the challenge that Russia faces. Our country played an important role in the development of the territory and subsoil.

Having studied the scientific works of experts, it can be noted that the Arctic topic has not yet been touched upon. But the main trends in the Arctic issue in Russia and foreign countries are becoming more and more relevant. The solution to long-term problems that are of fundamental geopolitical importance for the Arctic states is increasingly associated with the development of the Arctic territories. This trend stimulates special attention of countries to the development of the territory and nature of the Arctic. The question posed is currently becoming more relevant, so I want to work on this problem in the future.

Resilience is a relatively new approach to urban development compared to sustainability. They complement each other: the difference is that the concepts of sustainability work on stable, given trajectories, while resilience is responsible for the survival of the city in times of crisis, at bifurcation points, and at changing development trajectories. This aspect was examined in detail both in our previous works and in the works of colleagues (in particular, a slightly different view of the relationship between resilience and sustainability is given in the works, therefore a detailed analysis of the concept of resilience itself is not included in this article).

Introducing the concept of resilience for Arctic cities is especially important. Earlier works allow us to confidently assert that Arctic cities are characterized by increased vulnerability both in terms of the natural environment and in the sphere of socio-economic development, therefore, here the analysis of the possibilities of overcoming crises is more important than anywhere else. The topic of resilience is especially relevant for the Russian Arctic, which has experienced absolutely unprecedented transformations in its settlement system over the past quarter century.

Let us note that the very topic of the resilience of various social, socio-ecological systems has been relatively developed, including for the Arctic, but there is almost no work regarding the cities of the Arctic, which have a number of specific features. The novelty of this work lies, firstly, in the very treatment of the topic of the resilience of Arctic cities, and secondly, in the development of a comprehensive methodology for its analysis, including the characteristics of permafrost and climate, migration indicators, transport and geographical location, economic structure and features of small-scale development. business, organization of heat supply systems, residential development, innovation activities, administrative management, etc.

Main part

The problem of choosing parameters for assessing resilience is rooted in the ambiguity of the term itself: at the moment there is no consensus even on a term suitable for use in Russian. In turn, the ambiguity of the term “resilience” is largely due to its dual origin: the term arose in ecology and almost simultaneously in psychology (and in these industries the concept of “resilience” was established in Russian), and then was transferred to economics and economic geography (where discussions arose regarding not only the translation of the term, but also regarding the variability of its content). We would like to preserve the original meaning of the term as much as possible - as much as possible when transferring it to geography - and follow the tradition of translating the term resilience as “resilience” so as not to interrupt the continuity with ecology and psychology. In the practice of analyzing urban resilience, in turn, two main approaches have emerged, each of which has both advantages and disadvantages, namely:

The first approach takes into account the complexity of the urban system, including environmental, managerial, behavioral, and economic aspects. However, adherents of this approach do not generalize, working at the micro level with individual cities.

The second approach is to quantify resilience using large data sets, however, resilience is essentially reduced to purely economic aspects. In general, the criterion for demonstrating resilience is the dynamics of population and/or gross product. Various parameters are tested for the explanatory power of these changes, although there are variations in analysis techniques. For example, R. Martin used a set of two indicators to calculate resilience: resilience (the ability to maintain initial economic indicators during a crisis) and recovery capacity. Some authors additionally used methods of proportion shift, or statistical analysis of mutual influence based on the obtained indicators. The strength of such an “economy-centric” approach is the unconditional proof of the role of one or another factor in shaping the trajectory of a city’s passage through the crisis, and the weakness is the narrowness of the scope of analysis.

The similarity of both approaches is that resilience in both cases is assessed empirically - as a reaction to a crisis. In the first case, we are talking about a multicomponent set of resilience parameters that describes the structure of the city as a complex system. In the second case, the influence of certain factors on a narrow aspect of a city’s resilience – its economic vitality – is assessed, but for a large sample of cities that are comparable in terms of experience in overcoming a specific crisis.

However, taking into account the undoubted advantage of the second approach (the ability to compare cities with each other), we conducted a preliminary study using Martin's method, expanding the range of parameters used by including a number of natural, transport-geographical and other indicators. An assessment was made of the resilience of Russian Arctic cities in the long-term (1989–2017) and relatively short-term (2009–2023) periods. However, this "universal" approach turned out to be inapplicable to the Russian Arctic: the population of many cities has been declining for almost the entire period since 1989, making it impossible to measure the "crisis" itself. For the group of "oil and gas" cities, considered separately, the factors that positively influenced resilience were: the initial stage of the resource cycle, the status of a regional center, the high proportion of the indigenous population in the city's "hinterland," the large size of the city itself; a negative influencing factor is the location in the suburban area of a larger city. For other cities, positive factors include: the status of a regional administrative center, the pronounced role of certain branches of the public sector (defense industry, nuclear energy, etc.), the share of people employed in education, the role of a central location (by position in the settlement network). Interestingly, location on the seashore or a navigable river turned out to be negatively associated with resilience in the long term (obviously, the crisis of transportation along the Northern Sea Route in the 1990s had an impact). The obtained calculations were used for further analysis, however, the obvious limitations of the second approach to assessing resilience - through a universal criterion - forced it to be abandoned.

As a result, an attempt was made to use a mixed approach: from the first of the above-mentioned approaches, ideas about resilience as a function of the structure of a multi-component city system were taken, from the second, the focus was on comparing a large number of cities according to common criteria. At the same time, it was necessary to move away from the actual assessment of resilience as a response to the crisis, moving on to an assessment of potential resilience based on an analysis of the characteristics of the urban system. In other words, from testing resilience indicators for their role in overcoming a crisis, we moved on to the parameters of the urban system, which should presumably ensure the resilience of the system in the event of a potential crisis.

The legitimacy of this transition is determined by the given conditions for the selection of indicators for each of the individual subsystems: as a criterion for the selection of indicators, their connection with resilience was determined, shown in earlier studies on the characteristics of the response to the crisis of the corresponding subsystems (natural-ecological, economic specialization, life support subsystem) or discovered during our own field research (to describe the sociocultural subsystem).

The research methodology includes four blocks:

selection of cities for analysis;

compiling a multi-component set of indicators of potential resilience;

clustering of cities of the Russian Arctic according to a multicomponent complex;

according to a set of parameters of potential resilience.

Selecting cities for analysis. To form the sample, the authors used a previously tested technique: in addition to the 21st Arctic urban district, some of the largest settlements of municipal districts were added, subject to a number of conditions. Thus, a total of 27 settlements were included in the analysis.

Compilation of a multicomponent comprehensive set of resilience parameters for individual city subsystems was based on an analysis of literature on specific subsystems of the city, expert analysis of materials (including field socio-geographical studies) on the passage of a number of crises in Arctic cities.

The indicators were selected, first of all, according to the criterion of compliance with the theoretical model of resilience, which implies the ability of the urban system to withstand a crisis. This ability is determined by three main parameters, namely:

the first is readiness for change in a broad sense, accepting the risk of something new: in the event of a crisis, the development of the city can rely on new types and forms of activity;

the second is involvement in world processes (the term "involvement" itself is borrowed from the psychological interpretation of resilience and can be interpreted as involvement in external interactions, allowing both to receive additional resources from the outside and to monitor and objectively assess the development of the situation).

Let's illustrate this with an example. A global city, concentrating economic, political, information flows, has a higher chance of surviving any disasters than an isolated village - although it (in the absence of disasters) could maintain stability for centuries. Here again, the parallel between an ecosystem with changing population numbers of individual species, but surviving extreme changes in external conditions, and an ecosystem stable in population numbers, which, however, is vulnerable to extreme external changes, is relevant. Note that the parameters of involvement and readiness for change are necessary, but not sufficient: a single-profile city with high involvement in global economic relations is vulnerable, and for its viability a third parameter is needed - fate control - a widely used category in works both on viability, and in terms of sustainability of development, which implies the availability of resources and opportunities to influence the situation.

Each of the urban subsystems has its own characteristics of the formation of resilience, which are measured by separate parameters. Thus, in the economic subsystem, readiness for change is manifested in the ability to generate and/or perceive innovations (what is called "absorptive capacity" of the local production system in foreign literature on economic geography); in society, readiness for change is creativity, "openness of thinking," which is traditionally (according to Florida) assessed through indicators of tolerance, diversity (as a necessary resource for creativity), development of creative activities, etc. Control of fate in the case of a city is sufficient and diverse resources for the development of economic activities (system of economic specialization), trust (in the sense as it is used in sociology - trust) in the place among the local population (one can also recall Yi-Fu Tuan's concept of topophilia): in case of crisis and trust in the place, the community is ready to fight for the city rather than migrate to other places. At the same time, control of fate includes institutional opportunities to influence the development of the city (sociocultural subsystem). Administratively, a resilient city must have an effective system of self-government, and high administrative status is also desirable. Of the five urban subsystems identified in the model (economic specialization, administrative and managerial, life support, sociocultural and natural-ecological), the named parameters are not applicable only to the natural-ecological subsystem. The assessment of its resilience parameters was based on the idea of the natural-ecological subsystem of the city as a source of ecosystem services for other subsystems (including services for the provision of food, water, fuel resources, etc.), and resilience as an opportunity, first of all, a sharp increase (in crisis conditions) in the volume of ecosystem services (in addition, minimization of the risk of irreversible changes in the subsystem under conditions of external influences is taken into account).

The three parameters mentioned are based on a theoretical study and comparison of different approaches to assessing resilience - theoretical calculations were tested based on studying the behavior of individual subsystems of Arctic cities both in the specialized literature and during field studies; It is not possible to consider in more detail the rationale for the theoretical scheme for choosing parameters due to limitations in the volume of the article.

The selection of indicators was carried out in two stages: at the first stage, 35 indicators were selected that corresponded to the theoretical model of resilience, then, after a detailed analysis (including correlation analysis, paired scatterplots and the application of the principal component method), 19 indicators were selected (three -four for each subsystem).

Subsystem of economic specialization. An obvious and well-studied factor in a city's resilience (a factor in overcoming the economic structural crisis) is the level of diversification of its economy. Sectoral diversity stimulates economic interactions, promotes the innovation process and reduces the risk of fatal consequences for the city in the event of degradation of one of the sectors (in the conditions of the Russian Arctic, where a significant part of the cities were formed in connection with the development of nearby mineral deposits, the threat of depletion of the raw material base becomes of great importance) . A well-known factor in increasing the resilience of a city in the event of a crisis in the city-forming industry is the ability to search for innovation.

Based on these features, to assess the level of resilience, the well-known Herfindahl-Hirschman index, calculated using employment indicators by sectors of the urban economy (Rosstat), as well as the widely used indicator of patent activity, were chosen. In addition, for the first time, an indicator of the presence of innovative enterprises in the city was used, expertly selected from the database of SPARK organizations (in the context of quantitative assessment of the vitality of the city's economy, special attention is paid to innovative firms offering technological, organizational or marketing innovations.

Unfortunately, some statistical data appear to be distorted, in particular, the level of employment in the mining industry of some cities of the Yamal-Nenets Autonomous Okrug is clearly underestimated (their residents working in fields remote from the city, including those working on a rotational basis, are registered at their place of work). In some cases, this circumstance distorts the values of the Herfindahl-Hirschman index (an obvious example is the city of Muravlenko), although in general the index apparently gives an adequate picture. Partly to level out these distortions, a comprehensive indicator of the level of development of the mining industry was used - a score based on the following indicators:

a) the share of the territory within a radius of 150 km located within the boundaries of licensed areas (LU) for hydrocarbon resources and solid minerals;

b) the share of the territory within a radius of 150 km located within the boundaries of promising licensed areas of hydrocarbon resources and solid minerals (with a license to conduct prospecting work);

c) the number of license areas of different types within a radius of 150 km.

The apparent duplication of indicators (taking into account both relative and absolute metrics) is due to the peculiarities of the mining industry: licensed areas of hydrocarbon resources can differ in significant sizes (therefore, in places of hydrocarbon production, relative metrics are important), while areas for the extraction of solid minerals are usually

small in size (places of their concentration are detected through absolute metrics).

Life support subsystem. The heat supply system is critical to the resilience of human settlements in the Arctic climate. To assess the state of heat supply systems in Arctic cities, the authors collected data from heat supply diagrams. The ratio of the reserve/shortage of thermal power to the thermal load reflects the ability of heat supply organizations serving populated areas to promptly replace capacity that is out of service in the event of an emergency, and, to a first approximation, the ability to "control fate." Indicators of the ratio of losses in the heating network to the heat load, the share of local fuel, the structure of the fuel used (share of coal, oil, etc.) were also considered - however, it was not possible to collect a complete set of indicators for the totality of the cities studied.

In addition, data were used on the share of wooden housing stock in the total volume of multi-apartment housing according to the federal database "Housing and Communal Services Reform" (in the conditions of the Far North, multi-apartment wooden housing is, as a rule, low-quality housing stock of standard houses from the 1960s–1970s, non-prestigious "pieces of wood"). In essence, the selected parameter characterizes the share of obsolete housing stock. In addition, a scoring assessment of transport provision, described in detail in earlier works, was used. Other sectors related to life support (food industry, water supply, etc.), according to preliminary estimates, do not provide a strong differentiation of cities and were excluded from consideration.

Sociocultural subsystem. When assessing the resilience of a sociocultural subsystem, the authors started from the understanding of resilience in psychology as a combination of involvement in external relations, the ability to control fate and innovative changes. The first indicator, "fate control," is also widely used in sustainability research. Of the approximately two dozen indicators initially considered, four were selected. Involvement in external relations is assessed through the ratio of the average value of outgoing migration for 2017–2021. to migration turnover (the sum of those leaving and entering). It is not advisable to use the migration balance, since almost all Arctic cities have a large migration turnover. It was very difficult to choose the "control of fate" indicator. Foreign works, as a rule, rely on indicators of the development of democratic institutions - especially when it comes to the involvement of certain categories of local residents (women, indigenous peoples, etc.) - however, taking into account Russian political realities (in particular, the situation of control of elected bodies authorities of city-forming enterprises) it was decided to abandon such assessments. As a result, the number of small and medium-sized businesses per 1000 residents was chosen as the base indicator - not only as an indicator of the level of development of entrepreneurship and flexibility of economic behavior, but also as an indicator of the level of trust in the territory ("if we don't believe in the future of the city, we don't invest", which is clearly evident in field studies).

The Arctic cities of Russia are traditionally distinguished by great ethnocultural diversity, and this aspect, in the authors' opinion, certainly requires consideration. Therefore, it was decided to introduce an unusual indicator - the registered number of national-cultural autonomies per 1000 inhabitants. The experience of the members of the team of authors with the migration service and migrant adaptation services (A. V. Burtseva), ethnological monitoring and early warning of conflicts (V. P. Klyueva) allows us to expertly evaluate this indicator as a good indicator of the ability of ethnocultural groups to legally defend their interests in dialogue with authorities. Thus, this indicator largely reflects the presence of institutional mechanisms to control the fate of a multi-ethnic urban community, and in this capacity "works" better than indicators of ethnic diversity as such, as well as the territorial structure of migration flows (which were also considered at the first stage). The traditional indicator of the number of publications in the RSCI over the last five years per 1000 inhabitants was chosen as an indicator of the ability for innovative development; indicators of the number of registered users of the RSCI, as well as foreign databases of scientific publications, were also considered; the presence of a university and/or the number of students are all generally highly correlated.

Natural-ecological subsystem. Among the natural factors characterizing the resilience of cities (with one sign or another), the following components of the geosystem cover were included: the universal index of thermal discomfort, used to assess the severity of weather, the gully index - one of the most expressive quantitative indicators, revealing the potential for the development of mechanical denudation, due to the dissected relief and lithological conditions of the territory, the annual production of phytomass as an integral parameter is often used in assessments of the sustainability of the natural environment, since bioproduction characteristics determine the environmental protection potential of permafrost landscapes and the rate of their recovery after mechanical and aerotechnogenic transformation. Finally, the most important indicator was the permafrost distribution index, assessed through a combination of the distribution pattern (continuous, discontinuous and massive island) and the ice content of permafrost. With an increase in ice content and permafrost continuity (which also reflects the severity of the climate), the viability of the infrastructure decreases: the costs of its construction and maintenance are higher.

Administrative and management subsystem. The set of indicators that can characterize the viability

of the management subsystem differs from standard and fairly well-known indicators of the effectiveness of municipal management due to the specifics of the task. About a dozen indicators underwent preliminary calibration, and three were retained in the final list. The administrative status of the city and the level of its own budget revenues (average for 2017–2021) show the ability to control fate, respectively, in political-administrative and financial relations. Additionally, the indicator of the average number of employees in the sector "Public administration and ensuring military security" was also used; social security" in relation to the total number of employees, in% (average for 2017–2023). The indicator of budget expenditures per capita (average for 2017–2023) indirectly reflects the amount of financial resources that could potentially be used by the city itself to quickly respond to crisis situations.

The choice of indicators is reflected in more detail on the resource created within the project.

The primary selection of variables was carried out using the principal component method and analysis of paired scatterplots. Preference was given to indicators that have a high impact in the first five components, allowing cities to be differentiated and further divided into groups according to resilience using cluster analysis. A data set with selected indicators was prepared for clustering, namely:

– Variables with significant values differing by orders of magnitude were logarithmized;

– all variables were centered and scaled.

At the first stage, clustering was carried out using hierarchical clustering methods and the K-means method. The selection of the best number of clusters was made using the "shoulder" method with optimization of the cluster compactness characteristics, as well as the "silhouette" width optimization method.

At the second stage (due to unsatisfactory results obtained using classical methods), the t-SNE and UMAP methods were used to reduce the dimensionality of the data set (used when the principal component method is not able to identify the first two or three components with a high proportion of explained variance, including number due to the large number of variables). Using dimensionality reduction algorithms, the data was projected into two variables (analogous to principal components). Due to the element of randomness in the operation of the algorithms, each dimension reduction operation was performed in 1000 iterations. The GMN method was applied to the results of each iteration of dimensionality reduction for clustering with automatic selection of the optimal shape of clusters and the optimal number of clusters according to the BIC maximization criterion. The source data, code that reproduces the cluster analysis, and graphs are published as supplementary materials to the article on GitHub.

At the last stage, the resulting groups were expertly assessed for interpretability

Despite the multi-stage selection of variables at the first stage, the results of clustering using classical methods (hierarchical clustering and the K-means method) do not allow us to identify stable groups of cities that would be characterized by special values of the selected indicators and their combinations. As you can see, the silhouette width analysis method (right) falsely indicates 3 or 5 groups. They can indeed be identified, but, as can be seen in the same figure on the left, the compactness of clusters, regardless of the clustering method, decreases extremely smoothly, which indicates the instability of clusters - the slightest variations in the values of variables, replacement or exclusion of one variable from the analysis immediately lead to displacement a significant number of cities into completely different groups.

The conclusion about the impossibility of dividing the cities under consideration into stable interpretable groups using classical methods is also confirmed by the principal component method. Only half of the variance is explained by the first three components, and in order to explain at least 75% of the differences between cities (and, consequently, groups of cities) using variables, at least six components are required, each of which includes the influence of all variables. This leads to the impossibility of forming stable clusters.

Only when applying the methodology described above using the UMAP + GMM method was it possible to identify seven stable groups of cities and analyze the differences between these groups in terms of the studied variables. Comparison of the results allows us to identify groups of cities with relatively similar configurations of the resilience system. So, for example, the second cluster (Vorkuta, Norilsk, Dudinka) greatly "loses" due to the severity of natural conditions and transport conditions - although it has a fairly high level of small business development and diversity of society; there is almost no wooden housing here (the dilapidated wooden barracks that existed in these cities have been demolished). In general, the Yamal cities, Kola and Naryan-Mar (sixth and seventh groups) have a high level of budgetary security (in terms of budget expenditures per inhabitant), as well as a good level of small business development (due to well-organized state support). The "trouble" of the sixth group (Labytnangi, Tarko-Sale, Noyabrsk, Muravlenko, Salekhard) is a large proportion of multi-apartment wooden housing (these are low-quality two-story buildings of standard series, and not individual buildings); in this they differ sharply from most other "oil and gas" and other cities with high budgetary security (Gubkinsky, Novy Urengoy, etc. - the seventh group). The fourth group (Onega and others) are cities with a relatively homogeneous population, worn-out infrastructure and

high migration outflow. The fifth group consisted of obvious leaders in many respects - Murmansk and Arkhangelsk.

Because the Arctic Ocean receives much less solar energy compared to other oceans on Earth, it is all covered in ice (with the exception of the coastal areas of Norway and the Murmansk region, which are fed by warm currents). This is also facilitated by the strong desalination of surface waters due to the large volumes of runoff from northern rivers. In summer, the coastal waters of Canada, Alaska and Russia become ice-free. The central part of the Arctic Ocean is covered with ice all year round.

The processes of climate change in the Arctic, economic growth in the world and the development of technology determine the beginning of a new stage in the development of the region, the foundation of which is the growing interest in the mineral resource base of the Arctic, as well as the possibilities of using its transit potential. In Russia, the development of the Arctic zone is often viewed as a mega project that can become an economic driver.

The article uses the results of a project carried out within the framework of the program to support individual research at the Faculty of World Economy and International Affairs of the National Research University Higher School of Economics in 2021 on the country's growth. But as economic activity in the Arctic intensifies, the environmental aspects of its development become more and more relevant. According to the Intergovernmental Panel on Climate Change (IPCC), the Arctic is one of the four regions of the world most vulnerable to global climate change and one of the most fragile ecological systems on the planet. The consequences of the processes occurring here are likely to affect the global climate system.

Arctic ecosystems are extremely vulnerable to economic development. The flora and fauna of high latitudes are characterized by relative species poverty with relatively high genetic diversity, which determines the exceptional biological value of this region. Only about 1% of all species of living organisms live in the Arctic, but many animal taxa are most fully represented here. In particular, the Artik is home to all species of birds of the order Loons, 25% of species of salmon-like fish, 10% of lichen species and 6% of moss species.

Arctic ecosystems are ideally adapted to extreme temperatures, low light levels, short summers, permafrost and snowy winters, but they are especially sensitive to any changes in natural conditions, primarily caused by anthropogenic impact. At low temperatures, the processes of assimilation of any waste and pollution proceed slowly, and therefore ecosystems are not able to fully cope with the consequences of pollution even over hundreds of years.

The Russian part of the Arctic is the most developed and, as a result, the most polluted. The first stage of this pollution is associated with nuclear tests, active industrialization of the region and the development of the Northern Sea Route (NSR). Key sources of pollution were nuclear test sites on Novaya Zemlya, Siberian chemical plants, and the operations of the northern naval and icebreaker fleets.

The process of development of the Russian part of the Arctic, in contrast to the Canadian one, where the mineral resource base is developed on a rotational basis, was carried out by settling the polar regions on a permanent basis. This led to the formation of scorched spots around the city-forming factories. The northern territories also suffered from pollution from debris left over from geological and scientific work, as well as activities at military facilities.

The collapse of the USSR led to partial deindustrialization and emigration of the population from the Arctic zone, but environmental problems have not disappeared. On the territory of the Russian Arctic, there are 27 areas most susceptible to anthropogenic influence (11 on land and 16 in the seas and coastal zones), which are called “impact” areas. The main centers of environmental disaster were the Norilsk region (more than 30% of the total emissions of pollutants), areas of development of oil and gas fields in Western Siberia (more than 30%), the Murmansk region (10%), and the Arkhangelsk region (pollution with specific substances). Their ecosystems are subject to changes in chemical composition, pollution and degradation of soils, ground and vegetation, and the appearance of harmful chemicals in food chains; In addition, the incidence of disease in the local population increases.

There is an urgent need for large-scale work to dispose of industrial waste that accumulates in large quantities around enterprises. The development of the Arctic shelf poses enormous risks. The development of the NSR can change the habitat of marine animals, carries additional risks of oil and petroleum product spills, and will also be accompanied by emissions of sulfur and nitrogen oxides from the combustion of bunker fuel.

The processes of economic development of the region, the factor of climate change, as well as the special sensitivity of Arctic ecosystems to external influences determine the growing concern of the international community about the environmental problems of the Arctic. The United Nations Environment Program (UNEP) identifies three main ones: climate change and the melting of Arctic ice; pollution of the waters of the northern seas by oil and chemical runoff, as well as by maritime transport; reduction in the population of Arctic animals and changes in their habitat. Any economic activity in the region faces the need to take these problems into account. Companies operating in the Arctic are forced to follow separately more stringent standards, take additional measures to ensure the safety of production processes for the environment, face additional

pressure from environmental organizations, take into account changing environmental conditions, and interact with indigenous peoples whose activities are closely related to it.

Currently, the Arctic is experiencing climate changes that are unprecedented in speed and nature. Over the past few decades, the average surface temperature in the Arctic has increased twice as fast as the global average, although it is extremely heterogeneous across regions. In some polar regions of the Western Hemisphere it was 3–4 °C compared to the mid-20th century. In the 21st century Temperature records are recorded almost every year. The result was the melting of the ice of the Arctic Ocean. Satellite data from 1979 to 2012 show Arctic ice extent declining at a rate of 3.9% to 4.5% per decade. The area of September ice (i.e., during the period of minimum ice cover) has been decreasing over the past 30 years at a rate of 13% per decade. A sharp decrease in sea ice cover was recorded in September 2007 and 2012, when it amounted to 37 and 49% of the average ice area in the period 1979–2000. The absolute minimum ice was recorded in September 2012. Despite the fact that in 2013 the ice extent actually returned to normal and increased in 2014, the long-term downward trend is beyond doubt. Seafloor thickness in Arctic seas has decreased by an average of more than 40% since the 1980s, primarily due to the melting of perennial ice.

According to estimates by the Intergovernmental Panel on Climate Change (IPCC), on which Roshydromet also relies, under any warming scenario, the temperature increase in the Arctic will be approximately twice the global average. As a result, the processes of reduction will continue and thinning ice cover. According to Roshydromet estimates, further strengthening of the mutually influencing trends of increasing air temperature and reducing the area of ice cover will lead to the fact that in the 2035s. in September the ice may disappear altogether.

Climate change in the Arctic is exacerbated by the presence of intense positive feedback, namely:

Firstly, the gradual melting of ice leads to a decrease in the reflectivity of the earth's surface, which increases its temperature. Snow and ice reflect approximately 80% of incoming solar radiation, while the open ocean surface reflects only 20%.

Second, thawing permafrost releases large amounts of methane, a potent greenhouse gas. Participants in the climate conference of the parties to the UN Framework Convention on Climate Change (Lima, December 2014) were shown photographs of unusual holes on the Yamal Peninsula - with a diameter of 20 - - 30 m and a depth of about 10 m. The most realistic explanation for their formation is the melting of subsurface ice as a result increase in air temperature. Natural gas or methane from the permafrost could penetrate into the resulting container, and the resulting pressure would explode the thin soil layer.

Scientists predict that more and more such holes will form, and from them carbon dioxide and methane will flow into the atmosphere. According to UNEP, the permafrost of the Arctic zone contains 1,700 billion tons of these gases - this is twice what is currently contained in the atmosphere. Thus, as the Arctic region warms, positive feedback mechanisms will accelerate climate change processes both at the regional and global levels.

Thus, the melting of continental Arctic ice (primarily in Greenland, but also on the islands of the Russian Arctic) threatens to increase the level of the world sea. According to IPCC estimates, by the end of the 21st century. it could reach 80 cm from the current one, which would have catastrophic consequences for small island states, areas of large river deltas, as well as cities located in low-lying coastal areas.

Another group of possible catastrophic consequences—warming of polar waters, as well as desalination of the North Atlantic due to melting glaciers—could lead to a weakening of the Gulf Stream, which is extremely dangerous for the climate of Europe.

The consequences of climate change for the ecosystems of the Arctic itself are very serious. Over the past 34 years, the vertebrate population here has decreased by 10%, and the number of reindeer, which is extremely valuable to humans, has decreased by one third in the first decade of the 21st century.

Perhaps the most negative consequence of climate change in the region is the degradation of permafrost. It negatively affects the reliability and stability of building structures and engineering structures located on it, primarily economic infrastructure and main pipelines. In Igarka, Dikson, Khatanga, about 60% of infrastructure facilities are deformed, in Dudinka - 55%, in Pevek - 50%, in the villages of Taimyr - 100%. Up to 55 billion rubles are spent annually on maintaining their performance and repairs in Russia.

In Western Siberia, several thousand accidents occur annually on oil and gas pipelines, a fifth of them are caused by mechanical impacts and deformations due to uneven settlement of the soil during thawing of permafrost, leading to weakening of foundation structures.

Along with numerous risks, climate change also brings a number of positive consequences. The harsh weather conditions of the Arctic are becoming milder, which makes its wider economic development possible. Thus, climate change has become one of the key factors that made possible a new stage in the development of the NSR.

The most dangerous pollutants for the Arctic seas are heavy metals, petroleum hydrocarbons, organochlorine compounds, detergents, radionuclides, and polyaromatic hydrocarbons. Most of this

pollution is anthropogenic in nature. The reasons for the entry of heavy metals are the development of ore and hydrocarbon deposits, industrial, especially metallurgical plants, as well as maritime transport. Fuel spills also make a significant contribution to pollution of the Arctic Ocean.

Oil and gas projects on the Arctic shelf face a number of difficulties caused by severe weather conditions, short daylight hours, ice cover, icing of infrastructure, as well as the need to transport equipment over fairly long distances by sea. In many Arctic regions, existing infrastructure and facilities are insufficient to effectively and promptly respond to oil spill emergencies. Due to low temperatures in the Arctic, the resistance of hydrocarbons to decomposition and assimilation increases, and, as a result, the restoration processes of Arctic ecosystems slow down.

The greatest danger comes from oil spills. Thus, as a result of the crash of the Exxon Valdez oil tanker off the coast of Alaska in 1989, about 260 thousand barrels spilled into the sea. oil, an oil slick of 28 thousand km2 formed. This caused a sharp decline in fish populations, in particular pink salmon, and local ecosystems have not yet fully recovered. In addition, the disaster caused enormous public concern, and a class-action lawsuit by thousands of fishermen, landowners and businessmen resulted in a record fine of $2.5 billion (which was reduced to $500 million a decade later) against ExxonMobil.

However, it would be a mistake to assume that the alternative to tanker transportation – transporting oil and petroleum products from the Arctic by pipelines – will always be more environmentally friendly. According to Greenpeace, since 2003, Russia has seen a constant increase in the number of oil pipeline breaks leading to oil spills. Unfortunately, there is very little information about them; companies are not trying to make them public. According to an estimate summarizing data from publications of specialized companies and expert opinions, the volume of oil spills in Russia can reach 20 million tons per year. They will only increase in the future as pipeline infrastructure becomes obsolete and permafrost thaws.

Spills are possible not only during transportation, but also during drilling. The history of the development of the continental shelf knows a number of similar accidents with catastrophic consequences. The largest accident in the Gulf of Mexico in 2010 was an explosion and fire on the Deepwater Horizon platform, operated by BP. Its results were a disaster for marine and coastal ecosystems, and the total damage, according to some estimates, amounted to about $40 billion. So far there has not been a single major accident on the shelves in the Arctic latitudes, but scientists say that if something similar to what happened in the Arctic in the Gulf of Mexico, the catastrophe would be truly planetary in scale.

Taking into account the exceptional danger of oil spills in the Arctic, issues of their prevention and liquidation of consequences are reaching the international level. The 2013 Arctic Council Ministerial Meeting in Kiruna adopted an agreement on cooperation on Arctic marine oil spill preparedness and response, and at the 2015 conference in Iqaluit a framework plan for cooperation on preventing oil pollution from activities was signed. on the extraction of hydrocarbon resources and the intensification of shipping in the maritime Arctic.

The danger of oil spills in the Arctic also exists in Russia. Domestic drilling platforms are technologically imperfect, and this problem may worsen in the future due to the introduction of sectoral sanctions and the cessation of supplies of offshore drilling equipment from Europe. In particular, the Prirazlomnaya platform on the shelf of the Pechora Sea (the only one currently producing oil on the Russian Arctic shelf) is actually assembled in pieces - its lower part was built at Sevmash, and the upper part, where the main premises and the residential block are located , dismantled from a decommissioned Hutton tension leg platform, not intended for operation in Arctic ice.

In response to a request from environmental activists, Gazprom Neft states that the platform meets the most stringent safety requirements. In addition, the company has developed a plan for the prevention and response to possible oil spills, agreed upon with the Federal Agency for Sea and River Transport of the Ministry of Transport, the Ministry of Energy and approved by the Russian Ministry of Emergency Situations. The plan analyzes various risk scenarios and contains calculations of the costs of creating emergency units. In addition, the company purchased special equipment capable of collecting oil in ice conditions and eliminating the spill in a short time. In 2014, under the auspices of the Russian Security Council with the participation of the Ministry of Transport, the Ministry of Defense, the Ministry of Emergency Situations, the Nenets Autonomous Okrug, the Sovcomflot company and other organizations, large-scale exercises “Arctic-2014” were held, within the framework of which, among other things, actions were worked out in the event of a possible oil spill.

Despite all these measures, many environmental organizations insist that oil production on the Arctic shelf is inadmissible, at least until technologies for collecting oil spills in the Arctic latitudes are developed. In 2015, the Russian branch of the World Wildlife Fund proposed a 10-year moratorium on the development of oil reserves on the Arctic shelf.

The initiative was supported by a number of well-known politicians, officials, and economists. Their position is based not only on environmental, but

also on economic arguments, which are especially relevant in the context of low oil prices and sanctions from Western countries. Thus, according to E.M. Primakov, "on the Arctic shelf, production profitability is ensured only at a price of 100–120 dollars per barrel. In such conditions, should we speed up oil production on the Ice Ocean shelf? Some of our competitors have already taken such a pause. The United States drilled its last well on the Arctic shelf in 2003, Canada in 2005." V. A. Kryukov believes that "oil production in the Arctic is not only high environmental risks, but also an extensive development path and a high-cost activity, which in the current economic situation must definitely be abandoned. The country needs a modernization maneuver, support for truly innovative solutions, and not an attempt to continue to solve the problems of economic development using an extensive model."

In the Energy Strategy of the Russian Federation until 2030, "active development of the mineral resource base of the oil and gas complex" of the Arctic, including its shelf, is included in a number of priority tasks. It is often argued that maintaining the proper level of oil production against the backdrop of depleting fields in Western Siberia is, in principle, impossible without developing the shelf. However, the overwhelming majority of all proven oil reserves, according to Rosnedra, are not located on the Arctic shelf, but on the mainland of the country. The industry's problem lies not in the lack of new deposits, but in the efficiency of development of already discovered ones.

The main potential for successful development of the country's energy sector lies in increasing the efficiency of field development and transportation of hydrocarbon raw materials. Thus, an increase in the oil recovery factor from today's 38% by only 4 percentage points will allow the production of an additional 30 million tons (219 million barrels) of oil per year. For comparison: in 2014, only 300 thousand tons (2.19 million barrels) were produced at Prirazlomnaya.

Due to the fact that the development of the shelf corresponds to the interests of a number of large companies and has already been designated as one of the priorities of Russian energy policy, it is unlikely that the proposal for a moratorium will receive unconditional support, but it may at least push the state, companies and "green" groups to search for compromise. Norway and the United States have such experience, having imposed a moratorium on hydrocarbon production in especially fish-rich waters off the Lofoten Islands and in Bristol Bay in Alaska.

With regard to gas production in the Arctic, both environmental and reputational risks are incomparably lower. Firstly, the process of eliminating gas leaks is much easier than oil, and the environmental consequences are not as serious, since the gas dissipates quickly. Secondly, natural gas as the least dirty type of fossil fuel (it is non-toxic and is not accompanied by side emissions during combustion, except for CO_2, which, however, are still less than oil and coal) has a positive reputation in the eyes of the environmental community. Companies understand this well. Thus, the late president of Total, C. de Margerie, noted in one of his last interviews that in the event of an accident in the Arctic, the damage to the company's image would be too high. Therefore, Total is ready to participate, first of all, in gas projects, where the process of eliminating gas leaks is much easier compared to oil.

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It is important to understand that, regardless of the actual safety measures that companies take, the development of oil and gas reserves in the Arctic (both continental and especially offshore) is associated with huge reputational risks, as demonstrated by the situation with the disembarkation of Greenpeace activists from the Arctic Sunrise vessel on the platform " Prirazlomnaya" followed by widespread criticism of Gazprom around the world. Taking into account the fact that at present the public opinion factor has a serious influence on the decisions of investors, and the political situation contributes to the aggravation of the situation around any problems related to Russia, these risks should not be underestimated.

To date, a number of international agreements have been concluded aimed at protecting Arctic ecosystems. In particular, in 1992, 15 countries on the northeastern coast of the Atlantic Ocean signed the Convention for the Protection of the Marine Environment of the Northeast Atlantic. One of the objectives of the Convention is to prevent and eliminate pollution from marine sources and the adverse effects of offshore activities in order to protect public health and preserve marine ecosystems. In addition, the Convention declared the water area from Iceland to the Azores a protected area.

Russia is not one of the countries party to the Convention. She is involved in international cooperation on environmental protection in the Arctic as a member of the Arctic Council. Environmental issues occupy a central place in his activities. Thus, all six working groups (on eliminating pollution of the Arctic, on implementing the Arctic monitoring and assessment program, on preserving Arctic flora and fauna, on prevention, preparedness and response to emergency situations, on protecting the Arctic marine environment, on sustainable development in the Arctic) are functioning within the Council are related to environmental issues. At recent ministerial conferences of the Arctic Council, the topic of preventing oil spills and eliminating their consequences, as well as reducing soot and methane emissions in the Arctic, received special attention. A special task force has been created to address this last issue.

At the bilateral level, the Agreement on Assistance in the Event of an Oil Spill in the Barents Sea was concluded between Russia and Norway back in 1994. It includes a joint emergency action plan, and also involves holding joint exercises of national services on an ongoing basis.

Currently, there is increasing talk about the need to unite the efforts of different states, companies and non-governmental organizations in eliminating the consequences of natural and man-made disasters, for example, in the form of creating a global emergency rescue company (GARC), coordinating the actions of interested participants in the event of a disaster anywhere in the world. This approach is especially important for potential disasters in the Arctic, as speed of response is critical to preventing damage. Russia could be one of the main initiators and beneficiaries of the creation of GASK: it is vulnerable to disasters of various types, while it has extensive experience in effectively preventing and eliminating the consequences of disasters (the Russian Ministry of Emergency Situations is one of the best in the world), as well as a fleet of aircraft and rescue equipment, which it could provide to GASK.

In addition to the listed agreements at the regional or bilateral level, the Climate and Clean Air Framework Coalition, developed at the initiative of UNEP and including 46 participants, including Russia, can play a special role in protecting the Arctic environment. The goal of this organization is to reduce emissions of short-lived pollutants: "black carbon" (soot) (solid particles formed during incomplete combustion of biomass, wood, diesel fuel, mainly consisting of pure carbon, which adsorb solar radiation at all wavelengths), methane and chlorofluorocarbons. According to some estimates, "black carbon" is the second most important catalyst for global climate change after carbon dioxide.

The Russian Ministry of Foreign Affairs sent an application to join the Coalition back in August 2012, but for formal reasons the country was able to become its full member only in 2014. The Coalition is distinguished by flexibility and the absence of a rigid framework (voluntary choice by countries of directions and priorities of work, as well as voluntary contributions to the general fund). Its work scheme already allows for the implementation of projects to reduce emissions in Russia with foreign funding. At the moment, such projects are not among the priorities of the Coalition.

However, there is every reason to make the fight against emissions in the Arctic one of its priorities. The impact of black carbon is particularly strong in this region. Due to industrial production, forest fires, and fuel combustion, soot falling on snow or ice surfaces reduces its reflectivity, which in turn contributes to an increase in temperature.

In addition to the environmental value, as well as the potential financial benefits that Russia could receive, active participation in the Coalition also benefits it because the fight against soot emissions directly corresponds to strategic plans for modernizing the energy and transport sectors in the Arctic. Of course, to benefit from international cooperation on these issues, Russia must start with measures taken at the national level.

The development of scientific cooperation in the Arctic region will also be beneficial for Russia. The Arctic is the best place in the world for climate research. Its Russian part could lay claim to the role of a natural laboratory on a global scale, in which scientists from different countries could conduct joint research. This will make it possible to attract funding for the modernization of meteorological stations and other scientific infrastructure, including that necessary for the development of the Northern Sea Route.

The importance of the Arctic for Russia is difficult to overestimate. According to the "Fundamentals of the state policy of the Russian Federation in the Arctic for the period up to 2020 and beyond," the region is considered as a strategic resource base, and its development is among the main national interests of the country.

The socio-economic development of the region should not only not be accompanied by deterioration of the environmental situation, but also be carried out in parallel with the elimination of accumulated environmental damage and the rehabilitation of degraded ecosystems. "Ensuring environmental safety", "preserving and ensuring the protection of the natural environment of the Arctic, eliminating the environmental consequences of economic activity in the context of increasing economic activity and global climate change" are officially included in the priorities of the state policy for the development of the Arctic zone. And "maximum environmental conservation" was declared as one of the main principles, which means "the application of the most stringent environmental and environmental standards, the use of the most effective environmental technologies."

Today, the national environmental regulatory framework includes about 40 federal laws, approximately 1,200 government regulations and orders, as well as orders of ministries and departments. However, these documents apply, as a rule, to the entire territory of Russia, which makes it impossible to fully take into account the specifics of the natural and climatic conditions of the Arctic region. As a result, environmental requirements for Arctic territories are almost equivalent to those for regions less sensitive to anthropogenic impact.

The practical implementation of the directives and requirements laid down in the regulatory framework for the development of the Arctic region also leaves much to be desired. Thus, in Russia, approaches to determining the permissible anthropogenic impact on Arctic ecosystems have not yet been developed, which prevents the establishment

of objective requirements for the activities of economic entities in the region. In addition, business representatives note that the procedures for approving technical documentation are too bureaucratic and can last more than a year. As a result, it becomes possible to selectively apply legal norms and use them as a means of government pressure on business.

Another weakness of Russian environmental regulation is its excessive centralization. Environmental problems should be addressed where they arise – in municipalities and regions. This allows you to take into account the specifics of the problems of specific territories and find more accurate solutions. This principle is observed in most developed countries, including the Arctic ones - the USA, Canada, Iceland.

A serious impetus for the development of Russian environmental legislation could be accession to the OECD. It was the requirements put forward by this organization that became the basis for the formation of Russia's "road map" towards improving the regulatory framework in terms of environmental protection in such areas as waste management, preventing environmental damage and increasing environmental responsibility, ensuring environmental and industrial safety, access to environmental information, environmental monitoring. Despite the fact that currently negotiations on Russia's accession to the OECD are frozen, a number of changes to environmental legislation have already been launched.

An important specific feature of Russian environmental policy in the Arctic is its close connection with the military presence in the region. Since Soviet times, many environmental functions have been assigned to military units stationed in the Arctic. This is still relevant today: for example, units of the Eastern Military District in October 2014 removed 10 tons of waste (household garbage) from Wrangel Island and the area of Cape Otto Schmidt. Minister of Defense S.K. Shoigu also made a proposal for the participation of military units that work on Franz Josef Land, Cape Otto Schmidt, Wrangel Islands, Kotelny, Novaya Zemlya, Novosibirsk, in the Arctic cleanup program, carried out jointly with the Ministry of Natural Resources and Russian Geographical Society. A "regional environmental center of the Northern Fleet will soon be formed, which will carry out environmental monitoring and control compliance with Russian and international environmental legislation both in the places where the fleet is deployed and in the Arctic zone where our military personnel are stationed."

Russian energy companies are gradually taking more and more measures to reduce their negative impact on the environment. Thus, in 2013, Novatek's expenses on environmental protection measures amounted to 363 million rubles, with the bulk of the funds coming from the disposal of waste from its activities (about 109 million rubles). Gazprom Neft company in 2014–2016 implements a program for the reclamation of oil-contaminated lands, sludge pits and the processing of oil-containing waste. According to the latest report on sustainable development of the Rosneft company, even taking into account the commissioning of new assets, gross emissions of harmful substances are being reduced, primarily due to the Targeted Gas Program aimed at reducing the volume of flaring of associated petroleum gas.

Only part of the environmental activity of Russian energy companies is a consequence of legislative regulation. To a certain extent, we are talking about the social responsibility of business, and partly about reflecting the growing interest of the public (and, as a result, investors) in environmental issues.

In the Arctic, however, companies' environmental efforts are increasingly aligned with the concept of "shared values": they pay close attention to environmental issues, based on the understanding that these issues will be critical to them in the long term. In particular, it was the Arkhangelsk Pulp and Paper Mill, Novatek and Gazprom operating in the Arctic zone of Russia that became laureates of the Carbon Disclosure Project in 2014, which assessed the completeness of companies' disclosure of information on greenhouse gas emissions. Particular attention is paid to environmental safety when implementing the Yamal LNG project of the Novatek company. Gazprom is spending record amounts on climate research related to permafrost degradation, as it has a serious impact on the company's work in the Arctic. Both Novatek, Gazprom, and Rosneft actively interact with representatives of small indigenous peoples, understanding the need to find compromises with them as the main stakeholders of these companies in the region.

Of course, the initiatives being implemented are not yet enough to alleviate the problems associated with the environmental safety of the Arctic region. In Russia, we just have to build a comprehensive system of safety, prevention and elimination of the consequences of man-made accidents, combining the efforts of federal, regional authorities and business. The pipeline infrastructure needs to be updated. The problem of pollution of the Arctic by industrial waste remains acute.

Conclusion

Today, the topic of the Arctic is relevant, as there is a surge of interest in the Arctic in the world. Let's consider what this may be connected with.

The Arctic is an area of the globe that includes areas from the North Pole to the Arctic Circle or the northern border of the tundra. The Arctic zones were not initially divided, so they are claimed by five states - Russia, Norway, Denmark, Canada and the USA.

The Arctic is known to us all for its extreme conditions: permafrost, long and cold winters, short

and cool summers, the absence of conventional roads, the need to deliver almost everything necessary from the "mainland".

The peculiarity of the Arctic is that it is home to a number of unique animals: musk ox, wild reindeer, bighorn sheep, polar bear, lemming, wolverine, ermine, long-tailed ground squirrel, etc. Many of them are listed in the Red Book, so they should be treated with special attention and thrift.

Another interesting fact: there are no trees in the Arctic, but in its warm part dwarf shrubs, grasses, grasses, lichens and mosses are often found. Low summer temperatures result in low species diversity and small plant sizes. And in the Arctic desert there is practically no vegetation, since it is the northernmost of the natural zones.

Today there is great interest in the Arctic - many countries are ready to invest in the development of the rich natural resources of the macroregion. The Arctic contains a very large amount of undeveloped energy resources - oil, uranium, gas.

The extraction of natural resources in the Arctic is extremely complex and dangerous from an environmental point of view. In the harsh climate of the Arctic, the likelihood of emergency situations increases many times. The ability to eliminate the consequences of an oil spill, as well as its effectiveness, are complicated by numerous storms with high waves, thick fog and many meters of ice. If an accident occurs during the polar night, which lasts here for several months, then work to eliminate the consequences will have to be carried out in the dark. Another danger is icebergs, a collision with which can be fatal for an oil production platform. These conditions make it difficult to do business in the Arctic. Therefore, to attract investors, preferences (advantages, benefits) are needed so that it is profitable for them to develop the riches of the Arctic zones.

Currently, the problem of global warming is acute. Temperatures in the Arctic are rising twice as fast as in the rest of the world. This could lead to the extinction of many plant and animal species in the region.

Warming threatens the existence of Arctic indigenous peoples.

SIPN are the indigenous peoples of the North who live in the vast expanses of the North. Previously, they were called "small nations of the North." These include: Evens, Evenks, Chukchi, Dolgans, Yukaghirs, etc.

Their food and way of life directly depend on the flora and fauna. Without conducting traditional economic activities, it is impossible to imagine the full existence of indigenous peoples. Warming also leads to rising water levels, which makes life more difficult for some animals. For example, when searching and catching fish. All this leads to the fact that animals have to literally "survive" and look for food in areas where people live.

We believe that if the environmental problem is not solved, then the Arctic has no future. Therefore, to preserve the existence of indigenous peoples, as well as many species of plants and animals, it is necessary to take certain measures now.

The results of applying a whole series of methods for assessing the resilience and resilience potential of Arctic cities in Russia convince us of the absolute specificity of the Arctic city phenomenon: a significant part of them has a unique set of potential parameters of resilience, due to various combinations of the organization of subsystems of economic specialization, life support, socio-cultural, natural-ecological and administrative - managerial.

The conclusions of the work can be divided into conceptual and applied components. The conceptual conclusion is that the resilience of Arctic cities is formed each time by a unique combination of sociocultural, institutional, industrial, technological and natural-ecological parameters. It is interesting that resilience does not depend on the total population of the city, specialization, etc., which destroys many stereotypes regarding the patterns of urban development in general: in the Arctic, the largest cities are neither the most innovative nor the most comfortable in terms of the quality of the housing stock, etc.

The main applied conclusion is the fundamental inadequacy of standard solutions for the development of Arctic cities: with a relatively small total number, their totality is highly diverse. Increasing the resilience of each city should be planned based on the strongest subsystem of a particular city, around which a system of interconnection (and interchangeability in crisis situations) of urban subsystems should be built in such a way that the features of a strong subsystem create positive effects in weaker ones - through the flow of personnel and innovations, the use of common infrastructure, through the development of new types of economic activities based on the advantages of a "strong" natural-ecological subsystem, diversification of the economy based on the diversity of experience and external relations of a multi-ethnic urban community, etc. - depending on the specific city.

To find a balance between the economic development of the region and the development of its resource base, on the one hand, and minimizing damage to the environment, on the other, it is important to establish a dialogue between the state, business, representatives of small indigenous peoples of the North and environmental organizations. Shelf development should begin only when Russia is ready for it both economically and technologically. It is worth continuing to involve the military, but also foreign partners, in solving environmental problems, especially since now there are more and more

opportunities in the world to finance projects to prevent and eliminate environmental damage.

In order for the Arctic to be used as a driver for the country's economic development and to ensure Russia's full sovereignty over the Arctic territories, it is necessary to preserve the unique polar ecosystems and return the Arctic to the role it deserves - the role of the world's largest natural scientific laboratory, where nature and human activity are in a state of flux. stable equilibrium.

References:

1. Baburin, V.L., Badina, S.V., Goryachko, M.D., Zemtsov, S.P., & Koltermann, K.P. (2016) Assessing the vulnerability of the socio-economic development of the Arctic territory of Russia. *Vestn. Moscow un-ta.* Ser. 5. Geogr. 2016. No. 6, pp. 71–77.
2. Baburin, V.L., & Zemtsov, S.P. (2015). Evolution of the system of urban settlements and the dynamics of natural and socio-economic processes in the Russian Arctic. *Regional studies.* 2015. T. 50. No. 4, pp. 76–83.
3. Vinogradova, V.V. (2020). Thermal impact on the territory of Russia in the middle of the 21st century according to model data. *Izvestia RAS. Geographical series*. 2020. T. 84. No. 3, pp. 404–413. DOI: 10.31857/ S2587556620030115.
4. Goncharov, R.V., Dankin, M.A., Zamyatina, N.Yu., & Molodtsova, V.A. (2021). Cathedrals in the desert or strongholds? Diversity of cities and towns in the Russian Arctic by the nature of relationships with the surrounding territory. *Urban Research and Practice*. 2021. T. 5. No. 1. pp. 33–56. DOI: https://doi.org/10.17323/usp51202033-56.
5. Zhikharevich, B.S., Klimanov, V.V., & Maracha, V.G. (2020). Shock resistance of territorial systems: concept, measurement, management. *Regional studies.* 2020. No. 3. pp. 4–15. DOI: 10.5922/1994-5280-2020-3-1.
6. Zamyatina, N.Yu., & Goncharov, R.V. (2020). Arctic urbanization: phenomenon and comparative analysis. *Vestn. Moscow un-ta. Ser. 5. Geogr*. 2020. No. 4, pp. 69–82.
7. Shamalo, I.A. (2020). Vitality of Arctic cities: analysis of approaches. *Bulletin of St. Petersburg University. Geosciences.* 2020. T. 65. No. 3. pp. 481–505. DOI: 10.21638/spbu07.2020.305.
8. Smirnov, A.V. (2020). Human development and prospects for the formation of a knowledge economy in the Russian Arctic. *Arctic: ecology and economics.* 2020. No. 2(38), pp. 18–30. DOI: 10.25283/2223-4594-2020-2-18-30.
9. Lukin, Yu.F. (2015). Arctic: nanotechnology, military-industrial complex, investments, national idea. *Arctic and North*, 2015. No. 20, pp. 164-168.
10. Panichkin, I. (n.d.). *Problems of development of the Russian Arctic shelf.*
11. Leonov, S.N. & Shevareva, Y.S. (2017). Problems and prospects for the development of traditional types of economic activity of indigenous peoples of the North of the Far East. *Regionalistics* No. 2. – 2017, pp.26-45
12. Yudin, V.I. (2010). State policy of the Russian Federation regarding the indigenous peoples of the North at the present stage. *Power* No. 2. – 2010. – pp. 37-40

Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 29.02.2024 **http://T-Science.org**

Issue Article

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FEATURES OF MODERN SOCIO-HUMANITIES RESEARCH OF MOBILITY IN THE REGIONS OF THE AZRF

Abstract: *This article discusses the main developments obtained in the process of studying mobility practices in various nomadic communities of the Arctic. The analyzed provisions are based on the concepts of the anthropology of movement and were developed through a combination of methods of visual anthropology, design and various methods of recording movement, which made it possible to see the phenomenon of mobility in a new way and to comprehend its dynamic component. They will be presented not only as a result of the research performed, but also as theoretical tools inseparable from practical action. A scientific concept, therefore, is not just a crystallized concept of a research arsenal, but a tool directly applied in practice, receiving its testing, "cutting" and refinement in the context of field research and analysis of collected materials. It is the possibility of use in practical activities, which allows one to obtain qualitatively new results in the field of mobility research, that is the key distinguishing feature of the theoretical developments under consideration. It is the infrastructure, its internal (endogenous) and external (exogenous) elements that realize the states of stability (order) and chaos (disorder) in the development of systems, as well as the interconnected and balanced formation of two models of organization of regional spatial formations - hierarchical and heterarchical. But at present, due to the difficult geopolitical situation, the practical implementation of these proposals is becoming impossible. But we are confident that the results of this work will definitely be needed by the Arctic community after some time, when a reasonable approach to this problem will again prevail over manifestations of geopolitical ambitions.*

Key words: *Arctic, nomads, nomadism, mobility, movement, modularity, autonomy, minimalism, materiality, design, action, institutional infrastructure, decomposition of spatial development, transformation of spatial development, chaos in spatial systems, hierarchical model, heterarchical model.*

Language: *English*

Citation: Golubeva, O. A., Ermurake, M. R., Blagorodov, A. A., Prokhorov, V. T., & Volkova, G. Yu. (2024). Features of modern socio-humanities research of mobility in the regions of the AZRF. *ISJ Theoretical & Applied Science, 02 (130),* 67-84.

Soi: http://s-o-i.org/1.1/TAS-02-130-9 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.9

Scopus ASCC*: 2000.*

Introduction

UDC 332.71:338.62.

The problems and mechanisms of influence of institutional infrastructure on the processes of decomposition and transformation of spatial development of regions of various hierarchical ranks, including the Arctic zone of the world, divided on a national basis between Arctic countries, are very important, but little studied at present. Many scientific works are devoted to this problem, but they are reduced mainly to the traditional economic assessment of the "sectoral" effect of the activities of this very peculiar phenomenon and the concept of spatial economics. This is due to the fact that methodological and methodological approaches to the study of infrastructure, including its institutional components, should be built not on the traditional principles of the "mainstream" in economics, but, based on the system-evolutionary paradigm in modern natural science, and should be closely related to such an indicator of the development of spatial systems as self-organization. It is the infrastructure, its internal (endogenous) and external (exogenous) elements that realize the states of stability (order) and chaos (disorder) in the development of systems, as well as the interconnected and balanced formation of two models of organization of regional spatial formations - hierarchical and heterarchical. This methodological approach also finds application in the case of institutional infrastructure. In scientific and applied terms, it is proven that the activation of institutional infrastructure in the Pacific sector of the world Arctic is also associated with the creation of the Russian-American Council of the Bering / Pacific-Arctic Region (BPTR). These proposals were discussed at several international conferences and in various expert communities. The territories and waters of the world Arctic basin today represent in spatial terms a certain decompositional transboundary structure of macro-regional formations with their own nodes and centers of localization of economic and social development, divided according to national principles between the Arctic countries. Why decomposition? Because, if we understand decomposition in its classical scientific and methodological sense, that is, as a deductive method of structural division of a general problem into its more specific components, then it is precisely this historically established division of the Arctic region that is united in its physical-geographical and natural-ecological parameters into national components and represents this decomposition. It is necessary to take into account this current situation in various assessments of both the current and future development and development of both these national spatial components and the Arctic as a whole.

In general, administrative and political approaches to geographic regionalization and zoning are subject to serious criticism in the scientific literature, since they inhibit the manifestation of accelerating processes in the progressive transformations of spatial development, especially at the present stage of the new world technological order. In the overwhelming majority of cases, the division on the basis of nationality of a world economy that is essentially unified in its essence is an obstacle to the manifestation of global transformation processes in the development of both national and transnational structures. But in real practical activities we are dealing with precisely this approach, including in the Arctic region. As for this region, right now, due to the changed international situation, starting from the end of February of this year, Russia's interaction with a number of Arctic countries that are members of the Arctic Council is complicated. This is simply destructive for the cooperative ties that have developed over the past decades in the scientific-practical dialogue of the Arctic regions. On the web page of the Arctic Council, which most recently, in May last year, was headed by Russia as chairman and which, at the Ministerial meeting, adopted a historic document - a 10-year plan for joint work and cooperation until 2035, signed by all eight Arctic participating countries Council, it states: "The Arctic Council suspends all official meetings of the Council and its subsidiary bodies until further notice." In recent months, articles have appeared in the scientific circles of Western countries questioning the hard-won cooperative interactions and institutional ties in the international Arctic community, in particular, calling for the exclusion of Russia from the Arctic Council.

The Arctic community at this stage, more than ever in history, is being subjected to the most serious tests in attempts to establish a reasonable consensus in relations between the countries that make up this community, to identify the prerequisites for improving and mitigating contradictions and confrontations between interested states in this zone of the world. This will be a very positive factor for many countries in relation to the rational extraction of natural resources in this zone, and in the use of the Northern Sea Route (NSR) and the Northwest Passage (NWP), and in the development of coastal territories and waters, and in improving the livelihoods of indigenous peoples and the newcomer population, and in general in creating an atmosphere of trust and

cooperation, which is extremely important for many countries in Europe, North America, North-East and South-East Asia and others, which may have their own economic interests in the use of international transport and logistics communications. And the role of the international institutional infrastructure of the Arctic in resolving these issues, in our opinion, is of no small importance. Scientifically, we need to prepare for certain positive changes in the institutional and coordination relationships of the global Arctic community, which should appear in the future.

In recent years, the Arctic topic has become - as in the 1930s, the period of "conquest and conquest of high latitudes" - one of the most frequently discussed in the media and at official meetings within the country and abroad. There are several reasons for this, namely:

- global warming provides unique opportunities for the development of unparalleled natural resources;
- new shipping opportunities are opening up (the shortest route from Southeast Asia to Northern Europe lies through high latitudes);
- large-scale economic expansion in this vulnerable region is fraught with catastrophic environmental consequences;
- Intensifying global competition for dominance is causing the governments of the Arctic countries to seek to consolidate national sovereignty in those areas of "white silence" that may attract the attention of other countries in the context of a changed "balance of power" (the collapse of the USSR, the US desire for the status of "guarantor of the world order", rapid growth economic and political potential of China and India, attempts of new leading countries to participate in solving global problems, etc.).

Russia has been active in the Arctic for several centuries. According to intergovernmental organizations, Russia's GDP is about 60% of the total GDP in this region of the world. The Arctic's contribution to the country's GDP is 11-15%. But these impressive figures do not reflect the internal "technology" of forming such a significant contribution, which distorts the role of the Arctic in the country's economy. These technologies, as shown by the authors of this issue, vary greatly from country to country and in different historical periods.

From an economic point of view, the most important thing is the openness of the country and its economy to the outside world. Thus, in the 1930s, the USSR implemented a "…"closed" paradigm of Arctic development - with increasing economic autarky with the massive use of cheap forced labor." The situation with the formation of a development paradigm in modern conditions is much more complicated. Despite the change in socio-economic formations and models of political structure in our country, this paradigm has hardly changed. It is based on the following components, namely:

- Extraction, production and production of natural resources and products that are unique in their natural and economic characteristics; at first it was "soft junk", "gifts" of the tundra, forest and sea; then came the turn of gold and precious metals, diamonds and base metals, and, finally, oil and gas (to a lesser extent, coal). The fundamental feature of these unique natural resources is their relatively high prices and the possibility of "economies of scale," which allows them to be sold far beyond the Arctic.
- The extraction and production of a number of goods and services (hunting, fishing and fur farming products, a number of common minerals) are aimed at local or nearby markets. A significant part of the efforts to obtain them is of a non-commercial nature and is closely related to the traditional way of life of the peoples of the North (not only the indigenous people, but also the old-timers).

Unfortunately, attempts to introduce market relations into this area led to negative results - for example, a sharp increase in the number of deer in the Yamalo-Nenets Autonomous Okrug (which jeopardized the preservation of pastures and the future of traditional economic activities). The results of recreating the traditional economic structure of the peoples of the North on the basis of modern technical and intellectual capabilities are so far more than modest. The redistributive nature of the economy: the state sends funds to the Arctic to ensure the constitutional rights of citizens living there (medicine, education, government) and protect the sovereignty and territorial integrity of the country. It is very difficult to create a sustainable economy in the Arctic territories with such an internal "structure", since this is not so much a sectoral, but rather a spatial-zonal problem. Taking into account spatial features requires not only partnerships between the state, local authorities and the population, but also other approaches to managing the flow of financial resources. Now revenues from the sale of raw materials are accumulated in the "bins" of the largest companies, whose offices are located outside the Arctic, and the other part in the form of taxes forms upper-level budgets. With such a structure, the key question is what part of the income received from the development of the unique resources of the Arctic is returned to the territory. Obviously, the more successful the country's economy as a whole is - that is, the smaller the share of the "Arctic component", the greater the chances for the Arctic regions to claim a significant share of these incomes, which will improve the quality of life. Unfortunately, universal approaches to solving the problem have not yet been found. Moreover, not only in Russia, but also in other countries - from Alaska (USA) to the province of Finnmark (Norway). In Canada, a seemingly quite successful model has been implemented - the peoples of the North have the right to land, mineral resources and a portion of the income from their development.

However, its implementation is hampered by different understandings of the goals and directions of development of the Arctic. That is, for whom the Arctic has been a home and place of work for generations, they are wary of "fateful projects" that are poorly compatible, for example, with reindeer herding (seasonal migration), hunting and fishing (catch of valuable species of fish in northern waters has decreased many times). But residents of industrial cities and towns, as a rule, have a different view (sectoral rather than spatial). In this situation, the weighty word belongs to the arbiters - the state and institutions representing the interests of those living in the Arctic. When implementing industrial projects, it is necessary to take into account not only the present (return on investment), but also the future - the state of the environment and unique natural systems of the Arctic (it is difficult to assess in monetary terms the damage from the disappearance of unique species of animals, fish and plants). The era of "conquering and overcoming" left a difficult legacy. It is still unclear whohow and for what money it will eliminate damage to the natural environment - in a number of places in the Russian Arctic it is of a threatening nature. It is equally important, when determining the modern economic model for the development of the Arctic, to consider it as an organic (not just a raw material) component of the economy and life of the country. Our position is as follows: "The success of Arctic projects will largely be determined by how economic and financial relationships will be built with the development of related industries and production in other regions of the country." There is not and cannot be an Arctic economy without a deep and caring approach to the issues of its future, the development of its economy in the system of internal and external economic relations. Support zones, complex projects, priority development areas are only intended to "get the ball rolling" on this process. Development, a decent life, a favorable environment and harmonious relations between all participants in economic activities in the Arctic are the foundation without which it makes no sense to talk about the economy of this region.

Main part

Modern socio-humanitarian research characterizes the "mobile turn", the distinctive feature of which is the interpretation of mobilities as an independent reality, existing in the form of networked social relations. Important developments in this area are the works of John Urry, Manuel Castells, Noel Salazar and other researchers. In domestic ethnography, a separate direction was developed - the anthropology of movement. Under the leadership of Andrei Vladimirovich Golovnev, the Russian Science Foundation project "Mobility in the Arctic: Ethnic Traditions and Technological Innovations" was implemented, within the framework of which a series of monographs and articles was prepared, and an exhibition was held, conceived as a narrative about what it means to "be a nomad" .

The article discusses the theoretical developments used to study mobility in the Arctic, presented in the works of A. V. Golovnev, as well as members of the research team he led. The purpose of the article is not so much to summarize the main results of the application of conceptual schemes of the anthropology of movement to the study of nomadic communities in the Arctic, but to outline the potential for applying these developments within the framework of research practice. E. Eliot, R. Norum and N. Salazar note that, although life without mobility is impossible and any everyday interactions involve movement in space, the methods of anthropological research were largely formed by a static approach: in classical anthropology casts of a disappearing ethnographic reality were recorded, in a lesser degree, the research method was aimed at studying precisely the processes of constantly occurring changes. The theoretical apparatus developed by A.V. Golovnev and a team of researchers under his leadership makes it possible to abandon the static view of mobility and move on to multidimensional and multilevel modeling of movement. The system for recording the movements of nomads, proposed and tested within the framework of the project "Mobility in the Arctic," allows not only to deeply and comprehensively study northern cultures, but also to present them in a new visual and text format. At the present stage, thanks to the development of technical means, it has become possible to use new methods of recording and analyzing mobility, allowing maximum concentration on the study of dynamics. The movement can be recorded, its elements can be identified, and the slowdowns and accelerations of its pace can be analyzed. In this context, the combination of new recording methods and the non-static gaze of the visual anthropologist is very important. It was the synthesis of methods of visual anthropology, design and various methods of recording movement that made it possible to see the phenomenon of movement in a new way, to comprehend, first of all, its dynamic component. In mobility, both the actual movement in space and moments of stationarity, preparation for movement at certain points are important. However, the static component prevailed in the ways of interpreting mobility, looking at the results of movement rather than the process itself. There is great potential for the study of the physical elements of mobility, plotted on a map or diagram, supplemented by recording GPS tracks of movements, as well as video photographs of movements/actions - a special author's method of the anthropology of movement, the purpose of which is to create a multidimensional picture of movement with its peaks and pauses, personal and social trajectories.

Movement mapping is important for ethnographic research, but it is difficult to implement in practice. Recording a track on a GPS navigator and its subsequent decoding, description and interpretation is the most important task for future research projects related to the study of mobility. Drawing tracks of various categories of local residents on a map allows you to visualize movements and highlight gender characteristics of mobility. It is possible to visualize the movement in space of not only a person, but also an animal (deer, dog) or any thing (vehicle, portable home, tool).

Visual methods have enormous potential in mobility research. The idea of visualizing nomadic technologies within the framework of an atlas based on the results of research among reindeer herders in Chukotka, Yamal and the Kola Peninsula was a breakthrough. The authors made an attempt to present nomadic technologies in all their complexity and multidimensionality.

Visualization of mobility practices as a direction has enormous potential for future research and will undoubtedly develop due to the emergence and spread of new technologies. Filming camps from a quadcopter, 3D modeling, using micro- and macro-focus, recording GPS tracks and thermal imaging opens up great prospects for understanding mobility. The most important part of mobility analysis is changing the plan, studying macro- and micromobility. To develop these areas, traceology can be used, which allows us to consider various technologies at the micro level. Movement across the landscape leaves not always noticeable marks on things, similar to those left on them when processed with a tool; special equipment helps to see these marks. The use of new methods allows us to take a fresh look at the material basis of movement. The most important tool for studying the movement of nomads is visualization of their movements using rhythmograms. Two strategies apply here, namely:

1) measurement of the rhythm of nomadism by stops (camps) - in this case, the rhythmogram will have the form of bars, in which the duration of static periods is indicated, and migrations are designated as bar lines;

2) a beat consists of the duration and extent of migration, and stops act as beat features - this option corresponds to the nomadic tradition, in which the path is measured by migrations.

However, using only visual research methods, it is impossible to understand and interpret mobility: it is not enough to observe the movement of nomads, you need to empathize with it, feel it from your own experience. An important aspect of studying mobility in the Arctic is the analysis of the speed of movement of a nomad. Not everything he does is fast, but individual elements require rapid inclusion, prompt analysis of the current situation and action. Arctic nomads have developed a special "art of quick action." Within the framework of this area, the most important observations were made in the field of the anthropology of speed, which were developed in the research of cyber processes. Speed has its uses. In Chukotka reindeer husbandry, A.V. Golovnev identified three speed orbits, namely:

1) walking, which is supplemented by trips by vehicle;

2) the "middle horizon", which consists of the reindeer movement of the herd and caravan with a long summer season and short stops in the off-season;

3) "upper horizon", represented by air and road transportation.

All these three orbits do not remain unchanged; they include new tasks of movement. For example, the use of new vehicles requires periodic repair and creates the need to deliver spare parts.

Certain actions in the daily practices of a nomad require high speed. This is especially important for controlling the movement of the herd. Nomads develop and perfect a special art of alternating tension and relaxation in rhythms and arrhythmias - one of the most important technologies of Arctic nomadism. Rhythm in nomadism is a complex combination of bio-, eco- and techno-rhythms linked into a single composition.

The speed of various movements has the property of transforming phenomena and creating new ones. The speed and technologies of movement are changing not only in the tundra, but also in towns and cities. For example, in the town of Egvekinot in Chukotka, electric scooters began to be actively used in the summer, which have now become widespread in other regions of Russia. The possibility of such movements is ensured by existing and newly created infrastructure: in Egvekinot, for example, there is a relatively extensive network of smooth concrete roads, which creates the very possibility, or "affordance," of using new means of transportation.

The most important development within the framework of this direction is the combination of the concepts of space and time. This allows you to take a fresh look at the processes taking place. This kind of attempts had been made by theorists earlier and invariably provided new food for thought: MM Bakhtin, for example, understood by "chronotope" (a term introduced by A. A. Ukhtomsky and literally meaning "time space") the interconnection of temporal and spatial relations, artistically mastered in literature.

A. V. Golovnev in his thoughts about "merged space-time" relied, first of all, on the practice of representatives of Arctic nomadic communities. In the ideas of nomads who are constantly on the move, it is impossible to separate time from space. The active lifestyle itself contributes to the perception of space and time in an inextricable connection, one is thought through the other. The difficulty is that within the framework of scientific analysis it was much easier to

treat them as separate categories. The author observed similar couplings of time and space in the context of categories describing movements among the Evenks. For example, in Transbaikalia, fishermen and hunters often use the expression "walking around with a snack." This means that a person, moving throughout the day, returns to the same point in space.

A nomad is, at his core, a designer. The concept of "design" is interpreted quite broadly here. Design is a special, strategically important form of arrangement and movement of people, things and animals in space. The most important development is the understanding of design not as a result, but as a special form of interaction between a subject and material objects. This concept not only changes the language of science, allowing us to talk about the "design" of nomads, but introduces a number of essential elements into the analysis of modern processes, namely:

1) refusal to understand design "developments" as a static result that shapes practices and their perception by direct participants and observers;

2) looking at actions through the prism of design allows you not to separate the action from its result;

3) design takes the form of strategic action.

Design here is inseparable from practice and is formed within the framework of direct interaction with the environment.

Studying nomadic technologies makes it possible to update the tools of both the ethnographer and the designer. This kind of approach opens up interesting possibilities, allowing us to analyze, for example, the effect of overgrazing from the perspective of nomadic design. Adjusting the rhythm and method of movement of the herd allows you to adjust the interaction of the herd with the landscape, which determines both the condition of the animals (their weight, first of all), and the preservation of pastures. The design of mobility in nomadic communities varies depending on the landscape, the condition of the pastures, and the distance from industrial sites and administrative centers. The approach described above is potentially applicable not only to reindeer husbandry, but also to other livestock sectors. The way the herd is managed influences the physical impact that animal movement has on the landscape.

Based on the developments of A.V. Golovnev, we can draw a conclusion about mobility as a creative, constructive process. The very mobility of nomads, the methods of its organization, their strategic actions are the result of a creative synthesis of skills and constantly updated information about changes in the state of the environment and the movements of various agents. Design is thus part of everyday life, and not just a narrowly focused activity of designing aesthetic properties. Mobility always takes place in a specific space, but it actually participates in its creation. If you think of movement not as a set of specific movements from a point

A to point B, and as a set of parallel transformations of the arrangement of material objects relative to each other, then mobility can be interpreted as a creative process, that is, generating new objects and changing their physical states, where nomads are the designers of their space and movements in it. This approach allows us to concentrate on the actions of the nomad, his active involvement in the process of transforming material objects, and see him as a strategist, at the same time similar to a chess player and an artist. This, in turn, allows us to highlight both the practical and aesthetic components of the movement. The migrations of reindeer herders in the tundra are reminiscent of a game of chess, and sometimes a "move ahead" can be made strategically. To avoid mixing reindeer, the Nenets even roam "in a checkerboard pattern." The most important skill for them is driving the herd across the tundra, which is reminiscent of shipping navigation: it is necessary to prevent collisions and mixing of the herd with the herds of neighboring reindeer herders. Herd management is achieved through coordinated execution of maneuvers. The movement styles of northern nomadic reindeer herders are environmentally friendly. This effect is achieved not so much by regulating the size of the herd or searching for places abundant in food for reindeer (reindeer moss), but rather thanks to constant dynamics, a dynamic manner of grazing. The mode of transportation thus has important environmental and energy effects.

In recent years, the materiality surrounding the inhabitants of the North has undergone dramatic changes. Its transformation is brought about both by the actions of local residents and by various projects that influence the technologies for creating and the practice of moving things. The transition to the use of stationary houses in settlements significantly transformed the mobility practices of local hunters, reindeer herders and fishermen. Thanks to the development of the transport system and the spread of new material objects, this process can accelerate and lead to significant changes in the world of things around humans.

Material objects in the Arctic characterize certain forms of dynamics. A thing does not stand still and does not remain unchanged. Material objects created by man are the result of multiple movements and modifications. There is a constant distribution (contraction and dispersion) of individual objects in space, as well as their change and transformation during operation.

Mobility allows not only to constantly restructure the arrangement of things, creating their conglomerates, but also has an impact on the material objects themselves, changing their physical

properties. Thus, the things of nomads are created and transformed in constant movement.

The most important concepts for considering materiality are the concepts of transformability and polyfunctionality of things. The material objects used by northern nomads (vehicles, homes, buildings, clothing, tools, utensils) embody many practical functions. Arctic residents can use things in a new context, but the principle of poly functionality is preserved. For example, residents of the reindeer herding village of Amguema in Chukotka actively use yarangas during the warm season, installing them in close proximity to the settlement.

Installing a yaranga in this case serves several purposes, namely:

Firstly, this practice allows the tires of traditional dwellings to be preserved. Some local residents - usually retired reindeer herders - have their own family yarangas. During the cold season, disassembled yarangas can be stored in containers and sheds, but they cannot be kept in this form for a long time. Yaranga is a mobile dwelling; when used by reindeer herders, this structure is constantly in action, in motion. To preserve the yaranga, it must be assembled and disassembled, dried, and repaired;

secondly, yaranga allows you to significantly expand the area for subsidiary farming, making it possible not to be limited to territories adjacent directly to residential buildings.

In the Yaranga, skins are tanned, cut and sewn. Yaranga is also used for cooking: meat and fish are dried in it over a fireplace, and food is fermented. Residents of Amgue store fishing equipment, clothes and shoes, and sledges in traditional mobile dwellings. Yaranga is also used as a space for leisure with children, family, and friends. It is used by some local residents for overnight stays. Yaranga and all its contents, including religious things, must participate in people's lives and ritual activities. Without this, according to local residents, the household spirits of the yaranga itself will not only stop helping their owners, but will also begin to harm them. Thus, the installation of a yaranga aims to ensure the well-being of its owners. Finally, its installation near the village makes it possible to organize a “display” for outside observers, demonstrating and affirming the authenticity of the lifestyle of the local community, thereby attracting tourists. Amguem yarangas are used during holidays to greet guests. Thus, the yaranga as a material object is multifunctional, both in the tundra and near a populated area.

The Arctic is an area where proven technologies can be applied. What has been shown to be effective always becomes quite widespread. In the case of nomads and the movement technologies they use, a significant role is played by mobile, nomadic modules, which include not only a caravan of sleds, but also a herd of deer itself. Modularity is one of the key properties that characterize the methods of space exploration in the Arctic and allow saving time and energy costs when performing routine actions. The use of modules can significantly speed up movements.

Both local residents of the North and representatives of mining and transport companies use the same type and practice-tested strategies for using space. The development of space involves the use of various kinds of modular systems. Many module elements can be quickly replaced with similar material objects. In this case, we can talk about modules of various scales. The interchangeability of components is the most important element in preserving the action potential in conditions of scarcity of things. There is another strategy, widely used in the North, which allows one to maintain action potential in places remote from distribution centers. This is a strategy for accumulating substitutes, substitutes, and using alternative, additional systems.

The idea of modularity has great potential for ethnographic research. The most important element of the life of nomads is the nomadic module, an effective combination of heterogeneous elements that allows them to perform everyday actions. A module is what makes it possible to effectively develop space. It is modularity that allows representatives of northern communities to maintain relative autonomy. Nomadic communities are characterized by the “principle of autonomous mobility.”

The concept of modularity, however, is applicable not only to the description of the everyday life of nomads. In the Arctic, modularity is used both in the tundra and in populated areas. In the North, on their farms, local residents actively use mobile modules - for example, metal containers - as stationary structures. The principle of modularity is of great importance for the Arctic territories as a whole: the development of vast spaces became possible precisely through the use of effective modules - typical sets of things.

A Yaranga, tent or tent is a kind of construction set consisting of similar elements that can be replaced if necessary. This property - the ability to quickly replace individual parts - is fundamental. The lack of such an opportunity often causes skepticism among northern nomads about the innovations being developed and implemented. For example, many Chukchi nomads, residents of the Amguem tundra, told the author that the absence or breakdown of any structural unit of the new yaranga would not allow them to quickly, “on the fly,” carry out operational repairs of such a dwelling. Taimyr reindeer herders spoke with humor about the quickly dismountable yurts introduced in the late Soviet period, which were supposed to be used as an alternative to the beam on skids. According to the reindeer herders, these yurts quickly fell into disrepair, it was difficult to find replacement parts, so now the remains of such “innovations” are “scattered across the tundra.” Local residents always prefer verified and well-tested

technologies. Innovations take root, but mostly those that the local community can support on its own. For example, Dolgan reindeer herders adapted the balok on runners because it is easily made from local natural materials - wood, which is available in the forest-tundra zone, and tires made from reindeer skins. They also assemble stoves independently from scrap materials. Taimyr reindeer herders, for example, make the stove body from metal basins, which they buy in local stores.

The most important feature of the life of nomads is "material minimalism": they carry with them only those things that ensure control over space and the moving herd. It should be noted that the concept of minimalism is promising for analyzing the materiality of not only nomads themselves, but also residents of northern and any settlements remote from the centers of resource distribution, since it allows one to study the dynamics of materiality in conditions of scarcity. Many northern (and other) communities are experiencing supply shortages. People are forced to save resources by developing certain sets and complexes of things that allow them to effectively solve current problems while conserving resources. The strategy of economical spending itself presupposes the ability to achieve results at minimal cost. Such a strategy is the most important component of the technologies developed by representatives of various northern communities. The most important direction for future research is the study of ethnoergonomics, combining minimalism and practicality with elements of northern aesthetics. Things are commensurate with the body of a person, a deer, the shape of other things, they are combined with each other, allowing one to avoid environmental resistance when moving.

Minimalism is not only a feature of the material world, but also the most important component of motion technologies, as well as the process of production and modification of material objects. Technological minimalism is about minimizing the energy required to achieve results. Movement in space itself is an energy-saving technology. It is dynamics that make it possible to master maximum resources with a minimum of tools.

The most important conclusion from this provision is that movement itself can replace or supplement a material object. That is, movement has a certain form of materiality, and this is not only the result of movement, but also the materiality of people, animals, things and natural phenomena in motion. Movements are the force that changes the materiality of objects around a person. Northern nomads actively use such technologies. For example, while working among Dolgan reindeer herders in Taimyr, we witnessed corral work being carried out without installing a corral. The coordinated actions of people and dogs and the use of a certain landscape made it possible to carry out zootechnical work without the use of special buildings to restrict the movements of animals (corral). It is the herd nature of deer that allows humans to control the movement of animals.

Reindeer herders strive to avoid long stays of animals in one place. According to Dolgan reindeer herders, the places where corral work is carried out can be easily seen from a helicopter - fenced areas where reindeer have been concentrated for some time.

For a very long time they were still deprived of any vegetation. If corral work is carried out without the use of the corral itself, trampling is significantly less, since the concentration of animals in one place is lower and for less duration.

Dynamism is another distinctive feature of northern communities. The state of dynamics creates a special effect that manifests itself in the everyday actions of representatives of nomadic groups: nomadic technologies become effective and manifest their advantages precisely in dynamics. At the same time, those technologies that are effective in static conditions are not always effective in dynamics.

Movement consists of a certain set of practical operations. In this sense, the study of mobility requires attention to the category of action and the analysis of its motivational scheme. In the ethnographic analysis of movement, not only field observation is important, but also phenomenological (hermeneutic) perception and interpretation of the modules of motives-decisions-actions. The action of a nomad is the result of an assessment of a constantly changing situation and a non-static analysis of it. The category of action involves the active inclusion of representatives of the communities being studied in building their own space development strategies, which are based on a set of practical actions that are constantly adapted to current conditions.

Many principles used by residents of the North and involved in mobility practices are applicable in practice and allow them to save resources in conditions of scarcity. Ethnographic research on mobility provides an opportunity to focus on the role of local residents in creating the conditions for the potential for movement or motility. Ethnography allows one to identify and explore the key principles used by local people in their practices, and to consider resources and energy processes at a level commensurate with the individual. A person who consciously adjusts his motivational-activity scheme has enhanced project and activity potential. Skills, reflexivity and knowledge allow representatives of northern communities to change directions of activity depending on the current situation.

The advantage of Arctic cultures is precisely their mobility, which allows them to cover a vast space and develop the resources scattered throughout it. In the process of interaction with other people, animals, and the landscape, Arctic residents have the opportunity to take active action in conditions of resource scarcity. In their movements, Nenets reindeer

herders rely on the "principle of dynamic cooperation," which consists of uniting the efforts of various social agents within the framework of migrations. With such unification, the Nenets family retains autonomy and can migrate and, if necessary, join another camp. This principle works in a similar way in other Arctic communities. For example, Dolgan reindeer herders unite during summer grazing, and after corral work at the end of August they split up and graze their herds separately. It is important to consider strategies of cooperation and mutual assistance in dynamics, since the result combined efforts is not only the arrangement of objects in the space of the camp, but also the process of movement itself (migration). During migrations (castlans, argish), it is very important to correctly distribute the roles. It is thanks to the correct coordination of actions, constant internal adjustment of the direction of movement that people, animals and things move in space. Features of the functioning of such a category of economic systems as infrastructure, issues of its influence on the final results of the development of the entire system as a whole and theoretically justified identification of infrastructure components (activities, industries, sectors, etc.) in each system under consideration, problems of the relationship between investments in infrastructure and economic growth and the diversity of organizational, legal and financial forms associated with the creation of infrastructure facilities have long been of interest to scientists. Many scientific works are devoted to such a phenomenon of spatial organization of society as institutional infrastructure. As an example, we can cite the article by Kh. N. Mallaev and M. T. Avramchikov, in which, based on an analysis of many works in the field of problems of institutional infrastructure, it is concluded that this category is understood mainly as a complex of industries and areas of activity that carry out macroeconomic regulation of the economy, supporting the most optimal macroeconomic proportions for the development of the national economy. A number of foreign scientists, in particular M. Ruth, adhere to approximately the same approach. As can be seen from the above examples, the methodology for studying institutional infrastructure is based mainly on sectoral approaches to its formation, related to the economic functions of its constituent activities and their "integration" into the system of institutional management of one or another spatial entity. This is essentially correct and has its effect. But a purely economic approach based on the well-known principle of "costs - results" according to the currently dominant neoclassical paradigm of mainstream economics to the general theoretical understanding of the category of infrastructure, including institutional, is not here, in our opinion, sufficiently scientifically grounded and promising. The phenomenon of infrastructure belongs to another scientific and economic direction. The methodological approach to the study of infrastructure (substructure) should be built on the basis of an alternative direction in modern economic science, namely, the symbiosis of evolutionary and system economic theories (system-evolutionary economics), which follows from the system-evolutionary paradigm in modern natural science. This direction and its main postulates are set out in many scientific works, starting with the fundamental works of theorists of evolutionary methods for studying economic processes, the systems approach and their followers.

Understanding the role of infrastructure in this approach should be closely related to such an indicator of systems development as self-organization, during which almost the entire life cycle of an emerging complex dynamic system is realized and the reasons why it comes to stagnation under certain critical conditions are identified. Such processes can only be realized in systems that have a high level of complexity and also have a sufficiently large number of elements, the connections between which have a branched scheme that is not rigid, but adaptive, which is precisely typical for infrastructure elements. A distinctive feature of these processes is their focus on the survival of the system, which should be expressed in the formation of its infrastructure, the external, exogenous elements of which are constantly aimed at "probing" and probing future options for its development, adapting the system and its main (basic) elements to emerging new conditions its functioning. Let us emphasize once again that the concept of infrastructure from a theoretical point of view cannot be explained in neoclassical economics. As you know, this term was introduced into modern economics from military science, which primarily uses a systematic approach to the development and evaluation of military strategies. This term has taken root in classical economics; it is now used by both scientists and practitioners in various fields of economics. But the specialists who use it usually do not think about the fact that when using this term, they unwittingly move to another platform of economic research, into the sphere of systemic analysis of economic processes. After all, speaking about the infrastructure (substructure) of any economic system, it is necessary, first of all, to quite clearly define the very structure of this system - sectoral, spatial, combined or other, which in itself is a difficult problem. In general, infrastructure is a system-wide concept, the use of which is necessary when analyzing systems of both abiotic (inorganic, nonliving) and biotic (organic, living) order. This concept relates to general systems theory. It can be assumed that it is the infrastructural elements that create a holistic picture of the world through their connections between abiotic and biotic objects.

This is a special and scientifically very complex subject for research, but it is here, as we see it, that lie

those reserves and mechanisms that are associated with the stability and adaptability of various hierarchical ranks of socio-economic spatial systems to fairly strong and sometimes destructive influences of natural and social environment. What do we generally mean by the infrastructure of such systems? These are specific accompanying (substructural) activities through which the movement of material, energy, information and other resources is carried out in order to interconnectedly ensure the functioning of the basic elements of a given system for both production and social purposes at various hierarchical levels of spatial and economic entities, as well as their maintenance environmental and socio-economic sustainability, self-organization, survival and adaptability to the influences of the external and internal environment.

Moreover, the role of infrastructure elements in accordance with the principle of isomorphism of systems in each of these formations at different levels of the hierarchy is in principle identical.

The problems of systemic balance in Russia's spatial development, the mechanisms of self-organization and system formation of regional spatial formations and the synergistic effects of their infrastructure in these processes are the subject of many studies. As an example, we can refer to the works that have already been mentioned above, since they provide a broad analysis of research conducted in this area. The main criterion for the development of such systems is their survival in all natural and social parameters. To achieve rational indicators of vital activity in a given system, it is not at all necessary to have the highest indicators of its economic development, especially if this is associated with an "overload" on a number of natural and environmental parameters and infringement of the interests of certain segments of society. The main thing is to be able to accumulate resources and their reserves to adapt the system to new, both external and internal conditions of its development and existence, as well as to ensure sustainable reproductive processes while maintaining reasonable levels of consumption of accumulated resources in terms of public consumption in all respects.

If we methodologically use a structural-functional decomposition approach to the analysis of the entire complex of spheres of a typical spatial-economic system, which is an organic conglomerate of three basic components - "nature - man - society", then its spheres according to these components can be conditionally divided into the following, namely:

nature: cosmosphere, geosphere, biosphere, ecological sphere;

man: physical sphere, spiritual sphere;

society: noosphere, sociosphere, economic sphere, technosphere, political sphere, institutional sphere.

We emphasize that the structuring of these spheres is carried out only according to the criteria of their role in the economic development of any spatial entity. For example, with regard to such a sphere as the cosmosphere, here we are talking about its role not as a certain cosmophysical phenomenon (this is an object for research in the field of cosmophysics), but as about the possibility of its use for economic purposes, namely for the development of navigation satellite systems , Internet and specialized databases, for environmental observations, creation of interconnected wireless communication systems and for other economic purposes.

Each of the identified areas deals with a specific set of resources, which has, in principle, a similar structure in all areas. In an enlarged form, we can talk about two large groups of these resources: material and energy (natural and reproductive, characteristic of this particular area) and information, which naturally differ in scale depending on the specifics of this area.

Speaking about information resources, we understand that they are the basis for managing each area of spatial economic education, that is, they act as a specific resource base for its institutional substructure (infrastructure).

Of course, each area has its own sectoral institutional infrastructure. But the identification of an independent institutional sphere in such a component of spatial education as society shows that this sphere of a given spatial education aims to synthesize all the management functions of individual sectoral spheres. Without such an approach, it will be impossible to coordinate and direct the functioning of these spheres, developing according to their own sectoral laws, sometimes contradicting the single goal of development of the entire spatial economic entity, to achieve its ultimate goal. This can lead (and often leads) to chaotic processes in its formation, its uncontrollable stagnation and a bifurcation jump in an undesirable direction.

Techniques for truly systemic institutional regulation based on the creation and maintenance of appropriate infrastructure should be built on conceptual approaches, research on the basis of which has close connections with such concepts as chaos (disorder) and stability (order), reflecting the essence of two opposing but complementary models of system organization : hierarchical and heterarchical. The hierarchical model is associated with the evolution of the objects under consideration, which is initiated and developed on the basis of transformations and modifications of the upper level of the hierarchy, external to a given system. The heterarchical model is based on internal relationships of interdependence and interconnection of horizontal single-order subsystems that activate evolutionary processes based on adaptive self-organization.

Internal (endogenous) and external (exogenous) elements of infrastructure implement these states of

order and chaos in the development of systems. Internal elements are responsible for creating and maintaining order in the system, external elements are responsible for the openness of the system, which is associated with the introduction of a certain portion of chaos from the exogenous level, which forces the system in question to constantly improve the mechanisms of self-organization and adaptation to changing internal and external conditions. That is, hierarchical and heterarchical models in system organization and system education are implemented through external and internal infrastructure elements, their specific proportions, dynamics and intensity of interactions, which must be determined for each type of infrastructure at each time stage of the system self-organization process.

This approach is clearly visible in the example of such a well-known main transport infrastructure element of the global Arctic zone as the Northern Sea Route (NSR), to which many studies have been devoted. Regarding this main communication in our country, it was developed and approved in accordance with the Order of the Russian Government of December 21, 2019 No. 3120-r "Infrastructure Development Plan for the Northern Sea Route until 2035." Here it is worth paying attention to the fact that the decisions taken are aimed at creating mutually complementary infrastructure conditions, namely:

firstly, to modernize and expand the mainline communications itself, which is mainly related to technical and technological "vertical" sectoral issues of the development of the mainline itself, the construction of an icebreaker fleet and others (strengthening its hierarchical role);

secondly, to implement additional measures aimed at strengthening its influence on the development of the raw material base and supporting industrial centers of coastal regions for the long-term period (strengthening its heterarchical role).

It is this pyramid of infrastructural connections of various spheres and objects of natural and economic systems, penetrating them from top to bottom, that makes infrastructure problems extremely complex, requiring special methodological approaches and research methods. Many works of researchers are devoted to the development of Arctic spatial formations in our country and the world Arctic. The problems of the development of various institutional bodies and their infrastructures both at the national and international levels are also discussed, including issues of their formation in the specific conditions of the transboundary zone of the Pacific sector of the world Arctic at the crossroads of two oceans and continents.

During the period 2021–2023 The Russian Federation is the chairman of the international Arctic Council, a well-known leading intergovernmental forum, which, despite various geopolitical contradictions in the interests of the Arctic countries of the world, was designed to ensure their cooperation, coordination and interaction. This Council includes associations of indigenous people and newcomers to the Arctic, as well as many countries and organizations that are observers to the Council in solving common Arctic problems. This Council is often called the Arctic Parliament. It includes countries whose coasts directly face the Arctic Ocean - Denmark (Greenland), Canada, Norway, Russia and the USA, as well as Finland, Iceland and Sweden, whose territories are crossed by the Arctic Circle. These eight countries, according to the international classification, make up the Arctic zone of the world. The council also includes several expert and Task Forces groups. All of them are aimed at solving very important problems for the Arctic. The effectiveness of their activities in specific areas was very high, which is described in detail on the council's website. This council is an intergovernmental platform of the highest government rank. However, the activities of the Arctic Council today, due to the changed geopolitical situation, have come under severe pressure from its members - representatives of Western countries and North America. Some scientists adhere to a similar position.

Timo Koivurova, who is a professor and former director of the Arctic Center at the University of Lapland, writes: "The Arctic Council can continue to work without Russia. With some creativity, the remaining seven Arctic states can move forward with the vital work of this body. The article was published by Arctic Today, a respected news publication based in the United States that works with media outlets throughout the circumpolar north to provide readers with on-the-ground reporting, international news and perspectives on the Arctic community from one of the world's fastest-changing regions.

Alice Rogoff, who is the publisher of the same news source Arctic Today and co-founder of the Arctic Circle Assembly, writes: "The time has come for Arctic Council 2.0. Russia's threat to Finland and Sweden makes the existing paradigm of Arctic cooperation within the Arctic Council unworkable... If Russia's exclusion from the Council cannot be done officially, let it be done unofficially. This can be done by consensus of seven countries."

The Arctic, like many other areas of international cooperation and globalization, is currently becoming an arena for serious contradictions, new challenges, threats and tests. However, specific research developments in the field of problems of spatial economics in the Pacific sector of the world Arctic, reflecting the real situation in this region, show that there is no other way than strengthening international cooperation in solving problems of improving the natural and environmental situation here, and business activities, and the functioning of the most important there are simply no northern sea communications, and the livelihoods of the indigenous and newcomer

populations, and other important problems. Therefore, we continue to be of the opinion that it is the Arctic Council that can rightfully be considered today as a kind of truly "parliamentary" international institutional body of such a spatial and economic entity as the world Arctic basin. And we are confident that it is still necessary, at least scientifically, to continue to work on issues of improving the activities of this council, since its role and significance are very important not only for the Arctic basin, but also for the entire world community. And the appropriate attitude towards this council will be restored in the near future, and with the full participation in its activities of Russia, which occupies almost half of the Arctic territories and waters of the world. So, returning to the topic of this article, we emphasize once again that many governing functions can be seen in the activities of the Arctic Council, although this body, despite certain intergovernmental support for its functioning, was created as a kind of public forum for discussing pressing Arctic problems, which, of course, is not a fully institutionalized international management structure. As for the working, expert and task groups of the Arctic Council, they can be considered as its institutional infrastructure, through which resource, in this case information and resource, support the functioning of this institutional body, as well as finding consensus in combining hierarchical and heterarchical functions of external and internal elements of this infrastructure in managing the development of the Arctic region.

Each of these groups is aimed at an in-depth study of one or another problem, both the type of activity itself and the joint functioning of all types of activity of a given spatial formation as a unified system of nature, man and society in a given natural-economic zone. Moreover, it is here that their hierarchical (sectoral, coming from the interests of various types of activities and states) and heterarchical (regional, coming from the "interests" of the natural environment and socio-economic priorities of local development) essence is manifested, and here the mechanisms of their mutual coordination are worked out. These groups include leading subject matter specialists and experts on the issues under consideration in the functioning of the Arctic Council. They are the institutional "substructure" (infrastructure) of the Arctic Council. That is, the very essence of the activities of these groups shows the importance of both external and internal infrastructural elements of the Arctic Council, which is the institutional sphere of the entire Arctic basin as a whole. Over time, their focus on certain priority problems changes, but this is natural for the processes of adaptation and self-organization.

Along with the Arctic Council, a number of associations of North Arctic countries at the mega-regional level, down to the level of local governments, are currently operating in the global Arctic zone. Their work has intensified in recent years and is very productive. They include not only the immediate regions of the Arctic basin, but also a number of territories that are not directly included in the Arctic zone of the world, but have a significant political and economic interest in the development of Arctic spaces. These are, for example, organizations such as the Council of the Barents/Euro-Arctic Region (BEAC), which have shown their effectiveness, and the Northern Forum, in whose activities administrative bodies of the regions of the North Arctic countries of the world participate, as well as a number of other organizations with industry specialization.

As for the Northern Forum, it is an international non-political organization that makes a significant contribution to the development of interregional international cooperation between the regions of the Arctic basin. The Northern Forum has observer status with the Arctic Council.

Another very important and successfully functioning interregional organization in the European part of the Arctic zone of the world is the Barents Council, which is also an observer to the Arctic Council. If you look at the governing bodies of these interregional forums (Northern Forum and BEAC), at their secretariats performing these functions (by the way, very small in number), it becomes clear that they are their institutional structures. And all working groups that provide their activities with appropriate resources (in our case, specific information) act as the infrastructure of these institutional bodies.

Taking into account the considerations that were outlined above regarding the methodological concepts of infrastructure as a system-forming mechanism of regional spatial systems, the following conclusions can be drawn.

First of all, regarding conceptual approaches that are closely related to the relationships between categories such as chaos (disorder) and stability (order), and the concepts of two polar models of the organization of spatial systems - hierarchical and heterarchical. In the case of the considered institutional structures of the entire Arctic basin and its macro-regional components (Arctic Council, Northern Forum and BEAC), these approaches show the following:

1) their hierarchical structures are based on political and legal mechanisms for the functioning of national governing bodies, pursuing their national interests (these mechanisms are implemented through external elements of the infrastructure of the regions in question);

2) their heterarchical structures are based on the natural environmental and physical-geographical parameters of each region; they maintain a state of order that comes, first of all, from natural processes, and then from the characteristics of the socio-

economic development of each region. And these processes in the heterarchy of natural-social systems are supported by the internal elements of the infrastructures of these systems.

Regulating joint and coordinated actions of external and internal infrastructure functions for the purpose of sustainable development and rational self-organization of the entire system as a whole is a very complex process that covers many issues of regional development. But in any case, it presupposes finding a certain consensus between the national interests of border states (society), the interests of regional societies (people) and the "interests" of nature (nature), and therefore requires mutual concessions on the part of each interested subject of socio-regional development to achieve this consensus.

The application of the applied approaches to the study of Arctic spatial-economic formations also leads to the conclusion about the need to form a transboundary Russian-American Council of the Bering / Pacific-Arctic Region (BPTR) as an institutional structure in the transboundary sector of the Pacific Arctic. This Council will have a dual purpose and function:

- firstly, as a monitoring institutional body in a transboundary region at the crossroads of two continents - the Eurasian and North American and two oceans - the Pacific and the Arctic;

- secondly, as balancing the development of the Arctic zone of the Russian Federation (AZRF), its East Asian outpost in the system with its Western European outpost - the Barents Council / Euro-Arctic Region (BEAC).

The Bering/Pacific-Arctic region, that is, the Pacific sector of the world Arctic basin, and according to the national classification of the Russian Arctic, and according to the international classification of Arctic territories and waters, includes in the continental part the territory of the Chukotka Autonomous Okrug (ChAO) from Russia and the territory of the state of Alaska from its ridge of the Aleutian Islands on the US side, as well as exclusive (exclusive) national economic water zones bordering these territories in the seas at the junction of the Arctic and Pacific oceans.

But given the existing spatial-systemic and practical economic relations and processes, there are serious reasons to include the entire Kamchatka Territory in this transboundary North Arctic Pacific sector, although formally this peninsula geographically belongs partly to the subarctic territories and partly to the marine climate area. The territory and water area of the region play a large role in this transboundary zone both in the economic use of its resource potential (for example, in the extraction of marine resources) and in ensuring the functioning of the Northern Sea Route. The creation and development of the East Asian hub port of Petropavlosk Kamchatsky in the Far Eastern sea basin in a system with the Western European hub port in Murmansk creates opportunities for the balanced functioning of the two terminal ports of the NSR on this most important backbone element of the Arctic transport infrastructure, especially in transit international cargo transportation.

This position is confirmed by modern studies of structural-geological and tectonic objects in this zone, carried out according to spatio-temporal hierarchical principles and substantiated by the latest facts of geology and geophysics. They confirm that the Kamchatka Peninsula is an organic part of the geological structure of the Pacific sector of the Arctic. The administrative map of this sector, consisting of the Chukotka Autonomous Okrug and the Kamchatka Territory from Russia and the State of Alaska from the USA, as well as the exclusive economic water zones of both countries is presented in Figure 1.

Despite a number of problems in Arctic policy between Russia and the United States (Konyshev, Sergunin, 2018) and the difficult geopolitical situation, the project of creating the Bering/Pacific-Arctic Region Council (BPAR) as an institutional structure in the transboundary sector of the Pacific Arctic may be of quite high interest to many countries and regions not only of the northern part of the Pacific basin, but also of the European part of the North and Arctic zone and North-East and South-East Asia. At the initiative of the Institute of Economic Research, Far Eastern Branch of the Russian Academy of Sciences, this project was discussed in past years at two very large international wills of scientists and specialists in the field of studying the global Arctic basin.

Figure 1. Administrative map of the Pacific Arctic sector (in the square is the Bering Strait region.

The first meeting was the 24th meeting of the Russian-American Pacific Partnership (RAPP), held at the end of June 2019 in Khabarovsk and the second meeting was the IX International Forum "The Arctic: Present and Future" of the Association of Polar Explorers (ASPOL), which took place December 5–7, 2019 in St. Petersburg.

The structure of SBTR can be presented graphically in the form of a diagram (Figure 2).

It will consist of more than a dozen working and expert groups, including specialists from regions directly included in the SBTR, "complementary", mutually complementary regions from both Russia and the United States, as well as regions of observer countries. It is these groups that will make up the institutional infrastructure of the newly created governing body of the SBTR.

Its administrative divisions (Bilateral Bering Secretariat, Bering Regional Committee, Committee of Senior Officials) are aimed at performing organizational and managerial functions, that is, they will be its institutional bodies, and through its working groups there will be resource and infrastructure support for the activities of the council - information for decisions the main problems that are identified as priorities at this stage. Groups operating under the auspices of the Committee of Senior Officials represent the external elements of the institutional infrastructure that realize the national interests of the member countries of the council. The groups operating under the auspices of the Bering Regional Committee are internal elements of the institutional infrastructure that are aimed at promoting the interests of its regional components. Thus, these working groups are aimed at different levels of monitoring priority problems: external infrastructure - at the level of global international Arctic problems (hierarchical functions), internal infrastructure - at the level of regional problems of a given Arctic sector (heterarchical functions).

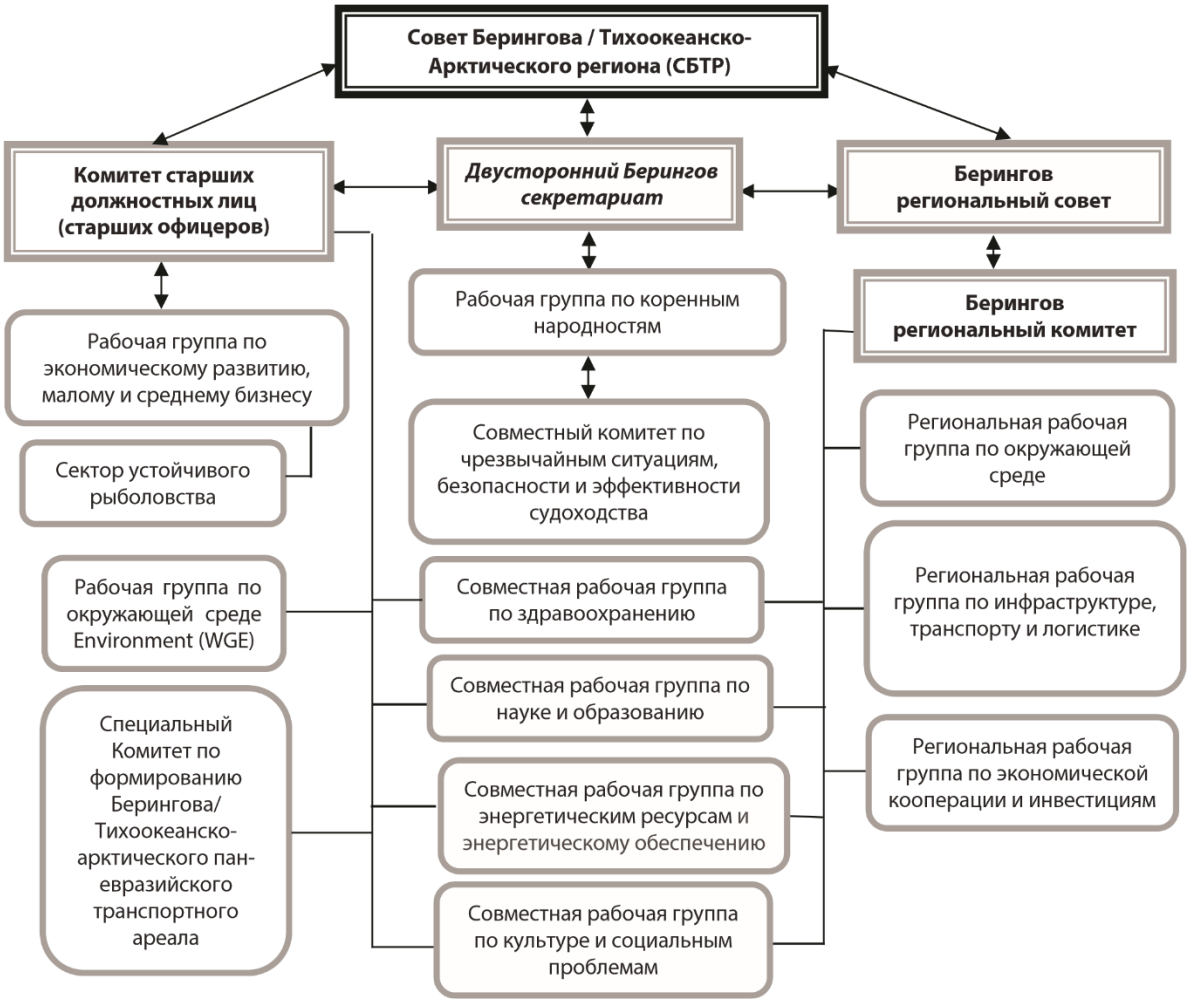

Figure 2. Institutional structure and infrastructure of the Bering/Pacific-Arctic Council (BPTR))

But for more detailed and coordinated work with these problems, working groups can combine their efforts in joint expert teams - joint working groups in which global (hierarchical) and regional (heterarchical) interests of the Council member countries are coordinated.

Established and newly created institutional structures and their infrastructures both at the global and regional levels of the Arctic basin are associated with the solution of one significant issue: are the institutional bodies of the Arctic countries and regions (Arctic Council, Northern Forum, Barents Council) taken into account in this entire pyramid? / Euro-Arctic region - BEAC, Bering Council / Pacific-Arctic region - SBTR), as well as their infrastructures, are not just formal, but real, very close co-evolutionary and coordination ties, sometimes cross-linked, which were discussed above and the need for accounting and regulation of which is dictated the very nature of the spatial formation called the Arctic?

At present, unfortunately, such a clear methodology, tools and mechanization

There is no interaction between institutional bodies of international intergovernmental and regional North Arctic forums and associations, which, naturally, does not make it possible to observe this organic unity of natural and social relations in the Arctic basin at both the regional and global levels.

It is in this regard that there is a need to create a specialized unit that would develop a similar methodology for coordinating the activities of all interstate and macro-regional forums and associations of the North Arctic countries and regions on the basis of the coordinated activities of their institutional structures and infrastructures based on the methodological and methodological approaches proposed in this article.

In this regard, it is possible to propose, as a specialized unit for developing a methodology for coordinating the activities of all institutional structures and infrastructures of the Arctic countries and regions, to create a temporary task force of the Arctic Council (Task Force), which will be entrusted with the execution of this task.

Upon completion of its work, the task force will cease to exist, transferring the methodology it developed and the corresponding tools for permanent use to the Arctic Council and interregional forums and associations.

As shown in the diagram, the task force of the Arctic Council to develop a methodology for coordinating its activities with macro-regional organizations in the field of institutional structures and infrastructures will implement its functions through constant contacts with the working groups of all major interregional forums and associations, developing tools for this coordination to focus their efforts to solve priority problems of the North and the Arctic.

Conclusion

Arctic communities are dynamic in a variety of ways. Representatives of northern nomadic groups demonstrate dynamism in the perception and development of cultural and technical innovations - new means of transportation, navigation devices, gadgets, tools, technologies, and materials have entered their everyday life. Technological innovations do not destroy, but develop nomadic culture in their own way. The technical and technological equipment of nomadic communities changes the routes of nomads and the material objects used by nomads. Representatives of the indigenous peoples of the North play an important role in producing conditions for vigorous activity and the formation of action potential - the most important condition for creative processes and transformations in the Arctic. The inhabitants of the Arctic are the creators of the things around them. Traditional dwellings, means of transportation, equipment of a reindeer herder, fisherman and hunter, outbuildings and containers filling the space of northern settlements are the result of "fine tuning" - practical debugging, polishing, adjustment to local conditions and landscape features.

Mobility, including nomadism, has historically been the basic principle of the development of vast Arctic territories. At the same time, nomadism should not be perceived as a shadow of the past; it represents the culture of the present and future, which does not disappear, but is transformed. The nomadic tradition itself, including mobile space-time strategies, values and technologies of nomadism, a special form of thinking, and rhythms of environmental and social behavior is the cultural heritage of the Arctic and the heritage of world culture as a whole. The cultural heritage of the indigenous peoples of the North lies, first of all, in the special technologies they use, high adaptability and mobility as a system of control over space and resources. The mobile technologies of the Arctic nomads contain a number of basic principles that make it possible to rationally use available resources. Locally developed technologies, such as grazing strategies, can achieve certain ecological benefits. The most important property of techniques and technologies developed in the Arctic is their practicality and effectiveness. Mobility also meets these criteria. The Arctic man acts as an active creator of his life and the surrounding materiality, and not only things have an energetic effect, but also the very actions of people, ensuring active interaction with material objects and the environment. With the help of multiple human efforts and practical actions, the Arctic has become a habitable space.

Mobility is a necessary condition for creation and creativity. It is in movement that local residents are able to express and realize themselves. Creativity in the North is the ability to invent and create material objects in conditions of scarcity, a limited amount of resources, implying the maximum use of existing material objects and infrastructure. The logic of transformation and creation of a material object in such conditions is largely determined by the experience of local residents.

Finally, scientific concepts and theoretical constructs themselves are an element of dynamics. They must be constantly tested, built into working schemes, supplemented and thus developed. The design of the approaches to the study of mobility considered in this work allows them to be adapted to the study of specific situations of dynamics and static states. A scientific concept, therefore, is not just a crystallized concept, a tool in the scientist's research arsenal, but a tool directly used in practice, receiving its "cut" and refinement in the context of field research and analysis of collected materials. It is the possibility of application in practice, allowing one to obtain specific new results, that is the most important distinguishing feature of the theoretical developments under consideration.

So, this article examines the influence of institutional infrastructure on the processes of decomposition and transformation of regional spatial formations of the Arctic at its global and macro-regional levels. The proposed and implemented methodological approach of structural functional decomposition to assessing the role of infrastructure as a system-forming element of spatial economic formations, regulating with its external and internal elements the state of chaos and order in the system, its hierarchical or heterarchical orientations and preferences, makes it possible to identify specific types of these infrastructures at different regional levels of the Arctic space.

From the analysis carried out, it follows that at this stage the historically established international decomposition proportions and imbalances in the development of the Arctic basin need to implement a number of transformational changes in its spatial development based on improving its institutional sphere. This, along with other areas for improving the activities of the Arctic Council, is connected, in our opinion, with the creation of the Bering / Pacific - Arctic Council - SBTR as an institutional structure in

the Pacific sector of the world Arctic with its infrastructure elements, which will significantly improve the balance of the formation of the regional components of the Arctic zone of the world as a whole and avoid emerging imbalances in their development.

Let us emphasize once again that, despite the difficult international situation and proposals from a number of countries to exclude Russia from all international Arctic structures, the implementation of the interests of Arctic states and regions in the global Arctic zone requires coordination of their activities on all natural, environmental and socio-economic problems, which is simply practically impossible to do without the participation of our country. Just a few months ago, some progress was made in terms of relations between Russia and the United States as cross-border countries in the Pacific Arctic sector. In particular, Russian Foreign Minister S. Lavrov, speaking at a meeting of the Council of Heads of Subjects of the Russian Federation on June 15, 2021, said that Moscow is open to the development of interregional cooperation with the United States, and is also interested in creating new regional structures to work on the Pacific dialogue with Washington. The conversation was about the Bering/Pacific-Arctic Council and strengthening our relations within the framework of the Russian-American Pacific Partnership (RAPP). "We are interested in creating new regional structures, including the Bering/Pacific Arctic Council, which involves the participation of a number of Russian Arctic entities and Alaska. While our American partners are thinking about this proposal," S. Lavrov emphasized then.

Also, Arctic problems found a very positive discussion during the meeting in Geneva on June 16, 2021 between the Presidents of Russia and the United States V. Putin and D. Biden. Putin, at a press conference after the summit, emphasized: "...I am deeply convinced that we can cooperate - and must cooperate - in this area. Russia and the United States are one of the 8 members of the Arctic Council, Russia chairs the Arctic Council this year. And moreover, between Alaska and Chukotka, as is known, there is also a famous strait. On one side is the United States, on the other side is Russia. All this together should push us to join forces."

And on the American side, these proposals also found their supporters, at least in the scientific community. One can give an example of a recent publication in the American scientific press by such a well-known scientist in the field of Arctic issues as Betsy Baker, a specialist in the field of international diplomacy with 25 years of experience, living in Alaska, an employee of the Wilson Center of the Polar Institute, director of the Research Department of the Arctic Pacifica (North Pacific Research Board), Alaska Marine Science Center. In her article, published quite recently - in November last year, she refers to the work of the author of this article and to the proposals prepared by the Working Group of the Russian-American Pacific Partnership (RAPP) for the creation of the Bering / Pacific-Arctic Region Council (BPTR), and very positively characterizes this initiative. The suspension of joint actions between Russia and the United States causes serious damage, first of all, to the solution of natural and environmental problems in such a "corner of the world" as the Pacific sector of the global Arctic, and also sharply reduces its role as the future largest transport and logistics natural channel in the Arctic. maritime communications of the NSR and NWP, which would allow it to become a serious competitor, for example, to the Suez Canal for connections between Asian countries and Europe. Joint ownership of the Bering Strait and rational and safe regulation of navigation in its zone would allow Russia and the United States to receive serious additional economic income, which would be possible only with sufficiently good neighborly relations between both countries. This would be important for all other users of these Arctic sea routes, who highly value the safety and reliability of the passage of their ships through these communications, in contrast to the risks, for example, of the passage of ships due to the same piracy on the route to the Suez Canal (Far Eastern and Pacific Arctic..., 2021).

From 2021 to 2023, the Russian Federation acts as Chairman of the International Arctic Council. Even if in the coming years there will be certain difficulties in its activities, our country will continue to work in accordance with the adopted documents on the development of the Russian Arctic for the future to significantly improve the processes of transformational changes in transboundary Arctic regions at the national level, which, naturally, will be associated with certain proposals for neighboring countries to coordinate the formation of their institutional structures and infrastructures both in the interests of our country and other countries that have their own economic interests in the Arctic zone.

References:

1. Bereznitsky, S.V. (2022). Fine-tuning your world. *Journal of the Siberian Federal University. Humanitarian sciences.* 2022. No. 2 (15), pp. 220–233.

2. Golovnev, A.V. (2009). *Anthropology of movement (antiquities of Northern Eurasia).* (p.496). Ekaterinburg: Ural Branch of the Russian Academy of Sciences; Volot.
3. Golovnev, A.V. (2020). The Arctic: a summary of 40 years of research. *Kunstkamera*. 2020. No. 3 (9), pp. 163–173.
4. Golovnev, A.V. (2018). Nomads of the Arctic: the art of movement. *Ethnography*. 2018. No. 2, pp. 6–45.
5. Golovnev, A.V., Kukanov, D.A., & Perevalova, E.V. (2018). *The Arctic: an atlas of nomadic technologies.* (p.352). St. Petersburg: MAE RAS.
6. Davydov, V.N. (2017). Ethnography of corral work in Taimyr (based on the results of the expedition in August 2016). *Materials of field research of the MAE RAS.* Vol. 17 / hole ed. E. G. Fedorova. (pp.67-90). St. Petersburg: MAE RAS.
7. Davydov, V. N., Davydova, E. A., & Goncharov, N. S. (2022). *Energy of the Arctic: ethnographic dimension.* (p.244). St. Petersburg: MAE RAS.
8. Kukanov, D. A., & Konkova, Yu. S. (2021). Nomads of the Arctic: a scientific project on the museum site. *Kunstkamera*. 2021. No. 3 (13), pp. 39–48.
9. (2021). *Far Eastern and Pacific Arctic. At the crossroads of two oceans and continents* / resp. ed. B. Kh. Krasnopolsky; Institute of Economic Research, Far Eastern Branch of the Russian Academy of Sciences. (p.248). Khabarovsk: IEI FEB RAS.
10. Zhuravel, V.P. (2019). Development of the Northern Sea Route. National and international aspects. *Scientific and analytical bulletin of the Institute of Europe of the Russian Academy of Sciences*. 2019. No. 2, pp. 119–124.
11. Kleiner, G. B. (2016). *Institutional management of the economy and society. Institutional economics and modern management*. (pp.35-51). Moscow: State University Publishing House.
12. Kleiner, G. B., & Rybachuk, M. A. (2019). Systemic balance of the Russian economy. Regional perspective. *Economics of the region.* 2019. T. 15, issue. 2. pp. 309–323. DOI: doi.org/10.17059/2019–2-1.
13. Konyshev, V., & Sergunin, A. (2018). Russian-American relations in the Arctic. Cooperation or competition? *World economy and international relations*. 2018. No. 62 (9). pp. 103–111. DOI: doi.org/10.20542/0131–2227–2018–62–9-103–111.
14. Kuznetsov, A., Nikitina, E., & Baronina, Y. (2019). The Changing Arctic. Vision of prospects for sustainable development of northern regions. *World Economy and International Relations*. 2019. No. 63 (9). pp. 112–117. DOI: doi. org/10.20542/0131–2227–2019–63–9-112–117.
15. Leksin, V.N., & Porfiryev, B.N. (2016). *State management of the development of the Arctic zone of the Russian Federation. Objectives, problems, solutions.* (p.194). Moscow: Scientific consultant.
16. Leksin, V.N., & Porfiryev, B.N. (2018). Russian Arctic today. Content innovations and legal conflicts. *Economics of the region.* 2018. T. 14, Issue. 4. pp. 1117–1130. DOI: doi.org/10.17059/2018-4-5.
17. Mallaev, Kh. N., & Avramchikova, N. T. (2017). Theoretical foundations of the formation of the institutional infrastructure of the region. *Management of social and economic systems.* 2017. No. 1, pp. 39–46.
18. Minakir, P. A., & Krasnopolsky, B. Kh. (2018). Economic mechanisms for introducing new technologies for the rational use of Arctic resources. *Regionalistics*. 2018. V. 5, no. 5. pp. 12–24. DOI: doi.org/10.14530/reg.2018.5.12.
19. (2018). *Socio-economic problems of the Russian Arctic in the research of institutes of the Russian Academy of Sciences*. History, modernity, prospects / edited by. ed. B. N. Porfiryeva. (p.802). Moscow: Scientific consultant.
20. (2018). *Features and problems of ensuring economic security in the Russian Arctic.* Scientific-analytical report / under scientific. ed. V.S. Selina, T.P. Skufina, E.P. Bashmakova, M.V. Ulchenko. (p.51). Apatity: Publishing house. KSC RAS.

Impact Factor:					
	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 8.771	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 02 **Volume:** 130

Published: 13.02.2024 **http://T-Science.org**

Issue Article

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ON THE IMPORTANCE OF LOCAL TRANSFORMATION OF URBAN REGIMES FOR COMFORTABLE LIVING IN THE REGIONS OF THE RUSSIAN AZ RUSSIAN FEDERATION

Abstract: *In this article, the authors analyzed the principles and patterns of mutual influence of socially significant projects for transforming the urban environment and urban regimes in the Russian Federation. Clarence Stone's concept of urban regimes was used as a theoretical framework. Based on the author's system of criteria of social significance, six projects for transforming the urban environment in four cities were selected and analyzed: Okhta Center and Tuchkov Buyan in St. Petersburg, Zaryadye Park and the development of fields belonging to the Timiryazev Academy in Moscow, a temple St. Catherine in Yekaterinburg and concreting the embankments of the river. Vologda in Vologda. If the initial phase of all projects took place in the realities of local urban growth regimes with the predominance of the interests of established coalitions of business and government, then the subsequent increase in the role of public activism in all projects and a change in goal setting under its influence led to the fact that during the implementation of projects there was a change in local urban regimes . It is shown that in five cases studied, during the implementation of projects, there was a transition of local urban regimes from "growth" to "progressive", and in one - from "growth" to a greater extent towards the "status quo" regime. The general principles and patterns of mutual influence of socially significant transformation projects and urban regimes in the Russian Federation are identified and described: competitive public interaction of all types of actors; change or relocation of the project as a spatial method of resolving the conflict; the prevailing shift from realizing the interests of government and business to the benefit of society; involving paternalistic instruments as a way to achieve consensus. Such conditions for the mutual influence of socially significant projects and urban regimes can develop at a certain period in any large Russian city, then we can expect results of spatial transformation similar to those*

described. The results of the study clearly demonstrate the beginning of the process of local transformation of the dominant urban regimes in the Russian Federation.

***Key words**: urban regimes, urban political regimes, transformation of the urban environment, socially significant projects, use of urban space.*

***Language**: English*

Citation: Golubeva, O. A., Pushkareva, V. V., Blagorodov, A. A., Prokhorov, V. T., & Volkova, G. Yu. (2024). On the importance of local transformation of urban regimes for comfortable living in the regions of the Russian AZ Russian Federation. *ISJ Theoretical & Applied Science, 02 (130),* 85-98.

Soi: http://s-o-i.org/1.1/TAS-02-130-10 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.02.130.10

***Scopus ASCC**: 2000.*

Introduction

UDC 338.44:303.24.

With the collapse of the USSR in the early 1990s. The process of transformation of the world order established after the Second World War began. The dominant vector was the destruction of the system of international relations, based on the documents of the Yalta and Potsdam conferences and which laid down the functional principles of international law and the functioning of international political institutions, including the UN and the Security Council. At the same time, as part of the "outlining" of the problem field of research, it is important to emphasize that the destruction of the Yalta-Potsdam system is a concrete manifestation of the transformation of the Westphalian (European) model of world order, the principles of which functioned for almost four centuries. We must agree with G. Kissinger, who defined the Westphalian system "as a "framework" of interstate and international order, covering various civilizations and regions, since the Europeans, expanding the borders of their possessions, imposed their own ideas about international relations everywhere."

As V.V. noted in his Address to the Federal Assembly of the Russian Federation in February 2023. Putin, "all the years after the collapse of the Soviet Union, the West did not abandon its attempts to set fire to the post-Soviet states and, most importantly, to finally finish off Russia as the largest surviving part of our historical state space." Currently, the tragic consequences of the "geopolitical catastrophe" associated with the ousting (economic, sociocultural, political and legal, etc.) of the Russian Federation from the former republics of the Soviet state have fully emerged, producing a number of conflicts that have not been resolved for several decades.

The doctrine of the "end of history" acted as an explanatory paradigm for the final victory after the collapse of the USSR of the liberal-democratic model of global peace, which presupposes the further development of national states, their regional associations and unions according to Western models of the "leading" countries of the world, led by the United States, which do not provide for alternative vision and implementation own interests, priorities, goals. Unfortunately, it is worth recognizing that in the process of forming the new post-Soviet Russian statehood, "our country tried to enter and partially entered into the Western system of reference points and coordinates," where the collective West develops and dictates the rules, imposing "parallel international law" on other countries.

From our point of view, one of the first attempts to reject the "unipolar world" on the part of Russia was demonstrated by E.M. Primakov, who turned the plane over the Atlantic as a sign of NATO's UN-sanctioned military actions led by the United States in Yugoslavia. Speech in 2007 by the President of the Russian Federation V.V. Putin at the Munich Conference laid the foundations for a foreign and domestic policy that defends Russia's right to economic, political, spiritual, and military sovereignty and rejects the existence of a "unipolar world."

The events that followed, including the reunification of Crimea and Sevastopol with Russia, the implementation of sanctions policies with the dominance of Russophobic ideology on the part of unfriendly countries, the achievement of the goals of the Northern Military District to denazify Ukraine and ensure the safety of life of residents of the Lugansk and Donetsk people's republics, Zaporozhye and Kherson regions, "provoked ", on the one hand, the process of consolidation of Russian citizens, increasing the level of trust in government institutions, primarily the President of the Russian Federation. On the other hand, they deepened ideological and value diversification within social groups and identified factors that reproduce the "split" between individual representatives of the elite and the majority of civil society.

Thus, within the framework of political science, the need to understand the conditions and factors of transformation of the modern system of international relations in the context of analyzing possible scenario approaches to the development of Russian society and the state as an integral part of the world community has become urgent. An absolute priority is the analysis of the main directions of Russian foreign policy, the possibility of cooperation with friendly countries, regional and global organizations, which would make it possible to implement the project of institutionalizing a multipolar world as a community of equal sovereign states and their associations.

In recent years, in Russian cities, the importance of large projects in the field of transformation of the urban environment has sharply increased, which for various reasons become "signature" for society, "image" for business and authorities at various levels, for the cities and regions in which they are implemented, and even at the international level - for Russia as a whole. It is enough to mention resonant (with different signs and for different audiences), even at the international level, examples of projects for placing the Gazprom tower in St. Petersburg, projects for transforming the space of Vladivostok or Sochi.

At the same time, with the development of business institutions, civil society and in the context of reforming the political system, the interests of the main actors of urban and social development in general are changing actively and not always unidirectionally, such projects are increasingly becoming an arena of conflict interactions between them, in which not only are they identified, but also the conflicting interests of the parties involved are resolved: society, business and government.

It is important that it is precisely such arenas, namely

firstly, they are as public and socially significant as possible;

secondly, they find themselves "fixed" for a long time in material space and, consequently, in the public consciousness;

thirdly, new effective tools for resolving conflict or conflict-free interactions of all participating actors in cities are developed and tested at them, concentrated in time and space.

The patterns and effectiveness of this kind of interaction between the main urban actors (bearers of special interests) are analyzed by the so-called theory (or concept) of urban regimes. Clarence Stone's classic definition describes an urban regime as "a set of arrangements or relationships (formal and informal) realized in the action of actors forming a coalition through which the community is governed." An urban regime is formed when intersecting interests in urban space begin to emerge in the interaction of actors.

It is worth mentioning that in Russian literature, Stone's English-language term "urban regime" is translated differently by researchers; the concepts of "urban regime" or "urban political regime" are encountered, which are not differentiated in Stone's concept. However, in our opinion, the term "urban regime" has a broader interpretation and more accurately describes the relationships and interactions - not only political, but also economic, socio-cultural - that are formed in the city. The creation of coalitions and regime changes can also be caused by non-political reasons and may involve more than just political processes. In this regard, for the purposes of this work, aimed at analyzing a wide range of actions of urban actors in terms of impact on urban space, we use the term "urban regime".

The topic of using the theory of urban regimes to analyze the processes of transformation of urban space in Russia (including in comparison with foreign practices) is not new. Today, there is a wealth of sociological research on urban social practices, social activism and participation. In the literature we will also find a large number of studies analyzing the effects of megaprojects. Among geographical studies, there are a number of works devoted to the problems of the image of geographical space, meta-geography and the integration of these ideas in the systems of natural and social geographical sciences.

In the domestic literature, there are studies that interpret the coalitions of business and government in the regions that existed in the 2000s as "growth regimes." E. V. Tykanova and A. M. Khokhlova note that they are formed on the basis of a tactical compromise between the interests of the authorities and large construction business. Such "growth machines" (coalitions of government and business) suppress other actors, deprive them of their voice, and society is forced to look for ways to consolidate with various political groups, parties, and urban protection organizations in order to influence the situation. O. Bychkova and V. Gelman demonstrate the diversity of urban regimes and their periodic dynamics, which may vary depending on the amount of political and economic resources. A change in these proportions, combined with a change in the role of actors, can affect the implementation of certain socially significant projects. At the same time, researchers note that Russian urban regimes are quite complex for obvious identification. According to A. Papadopoulos, the urban regime can also be local, since certain urban areas often have their own system of interactions between actors, which may differ from the citywide management system. Therefore, the authors use the theory of urban regimes using local cases as examples.

This study focuses only on urban transformation projects that have public significance. The concept of social significance has many interpretations. For example, from an economic point of view, a project that mitigates or solves problems of a social nature is socially significant. On the other hand, A.F. Ageeva believes that socially significant projects are, first of all, those projects whose implementation results have a significant impact on the socio-economic conditions of development, as well as priority projects that cannot be implemented without government support. According to M. N. Koroleva and M. A. Chernova, projects become significant when the authorities begin to listen to the public. One way or another, social significance arises in cases of active participation of actors in the project of transformation of the urban environment, especially the authorities and society.

From the point of view of influence on the urban environment, socially significant projects can exist in various forms. The most common today is redevelopment, which involves changing the functional purpose, as a result of which the object acquires qualitatively new properties that are more flexible to the current economic situation. Also closely related to the social significance of the concept is "renovation" - the renewal of territories through the redevelopment of abandoned areas with the possibility of reassessing the role and function of an important part of the city, "revitalization" - the revitalization of an area or object that is no longer functioning, "megaproject", under which in the literature more often This generally means any projects with increased costs. We leave out the term "urban conflict" (a clash of opposing interests, goals, views, ideologies between individuals, social groups, classes), although in most cases many socially significant projects will intersect with many urban conflicts. Any of these cases (most often redevelopment accompanied by a conflict-clash of actors) can come into the focus of our attention if it influences the formation of a new image of the city and significantly shapes its face in public space.

In relation to the stated subject, the next key element of the theoretical basis of the study, in combination with the theory of urban regimes, is the theory of urban transformation. More specific aspects of such research lie: in terms of analysis of the transformation of urban practices, redevelopment studies - in the field of theories of geo-urbanism; in the field of studying urban conflicts - in political conflictology in the field of coalition formation - in the sociology of social movements; in the field of studying their interaction - in the sociology and jurisprudence of the city. In relation to the case of post-socialist transformation that is relevant to us, L. Sikora and S. Buzarovsky prove that three different types of transformation in a post-socialist city have different natures and should be considered separately. These are institutional transformation, transformation of social practices and transformation in the morphology of urban space. They argue that while the first transformation (which includes economic and political institutions) has largely ended, the other two are still ongoing in post-Soviet cities.

According to this interpretation, large socially significant projects for transforming the urban environment in Russian cities precisely reflect the interaction of generally changed socialist institutional actors and actively changing social practices regarding the transformation of the morphology of urban space. For example, the unrealized construction of the Okhta Center led the city administration to the idea of limiting the height of buildings under construction in the center and semi-periphery of St. Petersburg, and the unrealized concept of building the complex of the Supreme Court of the Russian Federation on Tuchkovy Buyan aggravated the issue of the fundamental need to transfer federal authorities to St. Petersburg.

Finally, speaking about the special place of a socially significant project for transforming the urban environment, it is important to note that it can form an image, identity, a new image of the city in the public consciousness. The reputation and prestige of city authorities and the idea of city politics in the public consciousness may depend on it. In our study, the assessment of social significance is carried out by assessing the interest of actors, the participation of senior officials of the state and corporations, the reaction of the media, and the multiplicity of concepts for the development of the urban environment.

Socially significant projects change the essential content of the urban environment - during the transformation, the essence of urban phenomena is not just modified, but replaced with fundamentally new ones. Therefore, generalizing and supplementing the above approaches and definitions, by socially significant we mean those projects of transformation of the urban environment that have the maximum impact on changing and consolidating a new image of the city in the public consciousness, change the essential content of the urban environment, significantly correct the current public discourse and urban population.

The authors see the main goal of the study in determining the principles and patterns of mutual influence of socially significant projects for transforming the urban environment and urban regimes in the Russian Federation. A feature of the proposed study, in contrast to existing ones, is the focus on the aspect of the social significance of urban spatial transformation practices for urban development. The authors' task was to offer a new look at the mechanisms of transformation of urban space, without in any way claiming to cover the problem completely, as well as to identify the entire possible range of interactions under study.

Main part

The selection of key socially significant transformation projects in Russian cities was carried out on the basis of the author's methodology using the developments of E. V. Tykanova, A. M. Khokhlova.

As a hypothesis formulated on the basis of the mentioned developments and tested in the study, the authors identified the three most significant groups of criteria for assessing their mutual influence with urban regimes of the social significance of urban environment transformation projects, namely:

1) spatial (environmental) - defining projects in relation to the urban environment;

2) resonance and participation of actors - describing the parameters of social significance, distinguishing the projects under study from the entire set of projects;

3) transformational - classifying projects as transforming the urban environment.

The proposed groups of criteria describe all three aspects of the complex phenomenon being studied. In each aggregated group, one or more criteria are additionally identified that determine the social significance of the project for transforming the urban environment.

1. Spatial (environmental) criteria. This group consists of two criteria.

Criterion 1.1. A large territory redevelopment project localized in the city. Only redevelopment projects of certain urban areas are subject to consideration, that is, those associated with the emergence of new urban functions in the territories. Projects affecting only individual urban objects or newly developed territories (receiving a certain urban function for the first time) were not included in the consideration.

Criterion 1.2. Location in a socially significant location for the city. Deepening criterion 1.1, the authors focus on the fact that the city itself can be divided into locations that secure the status of the city and secondary ones. Socially significant locations, as a rule, include central, historical, publicly accessible and visited places, aesthetically or symbolically significant places. To evaluate the criterion, the authors use the "center-periphery" model already described and adapted for urban space.

2. Criteria for resonance and participation of actors. This group includes three criteria.

Criterion 2.1. The clash of interests of three main actors in space and reflection in all three public discourses - government, business and society. If at least one of the actors has no interest in the project, it will not be perceived as socially significant. It is the presence of this criterion that removes from the focus of our consideration federal megaprojects of urban transformation, such as the preparation of Sochi for the 2014 Olympics or Vladivostok for the APEC summit in 2012. As a rule, those projects that cause direct clashes of interests of all three actors have a complex public response — conflicts over the use of urban space.

In this case, socially significant transformation projects attract more spontaneous attention to the project from the outside, do not allow it to be resolved by the realization of the interests of one specific actor, and locally influence changes in the urban regime. In the study, we focused on those projects that were changed under the influence of social activism, since it is in these cases that the interaction of actors most clearly allows us to determine the existing urban regime.

Criterion 2.2. Participation of all levels of state and municipal authorities in public discourse. The most conflict-ridden transformation projects for actors do not allow the conflict to be resolved within the framework of the usual intra-city system of interaction "city government - city business - city communities". As a rule, in such cases, public significance becomes so great that it requires the involvement of external echelons of power in the discourse - in special cases, even the highest officials of the state. The existence of this type of decision-making refers to the concept of so-called paternalistic urbanism, which is very characteristic of Russia. In the present study, the authors use cases that fit the parameters of this concept.

Criterion 2.3. Significant resonance for the image of the city in public discourse, media and online media. The increased attention to the transformation project is largely due to the increase in the number of publications in the media, the level of media in which discussions are taking place, and the number of public events that form information occasions related to the possible implementation of the project.

3. Transformation criteria. The last group consists of three criteria.

Criterion 3.1. The process of changing the functional purpose of a spatial object in the process of redevelopment. If a new business center appears on the site of a business center, and a more landscaped green area appears on the site of an old park, then such a project cannot radically transform the image of urban space. It is important that the transformation project changes the essential content of the urban environment, significantly modifies the characteristics and image of the city, and gives actors the opportunity to obtain new spatial functionality.

Criterion 3.2. Change of project concept during implementation. The authors believe that the most significant examples of environmental transformation projects are those that, due to circumstances, do not find a final result for a long time, even in the event of intervention by higher authorities. Such projects are capable of forming an assessment of the quality of urban environment management both in the country and abroad; they have very complex positive and negative connotations among different actors. As a rule, change/adaptation of a project (as well as its transfer described below) in such cases occurs in the process of conflict communication between actors, which is perhaps the most significant indicator for assessing changes in urban regimes. In the present study, each change in concept marks the beginning of a new phase of the project.

Criterion 3.3. Transferring the implementation of the transformation project to a new location during the revision of the project. Of particular social significance are such projects, the functions of which are implemented in a new place as a result of a clash of interests of actors in the same space. The spatial relocation of the project can reduce the negative background associated with the previous location, and

there may also be a drop in social significance due to the loss of the previous conflict location and a general decrease in tension in the relationships between the actors.

As a result of selecting possible cases for consideration based on the described criteria, it turned out that there are many regional projects in Russia that fall under criteria 2.1 and 2.3. Suffice it to recall the conflicts surrounding the construction of alluvial territories in St. Petersburg, the development of the Nagatinskaya floodplain in Moscow, and the reconstruction project for the 1000th anniversary of Kazan. However, there were not so many projects in which there would have been any intervention from the federal level (criterion 2.2), which influenced a change in the concept of transformation or the transfer of project implementation to another location (criteria 3.2 and 3.3).

It was the criterion of intervention by federal authorities, together with the criterion of a radical change in concept, that turned out to be the decisive cut-off criterion. Based on the methodology described above, we identified only six such large cases (shown in Table 1).

Table 1. Socially significant projects for transforming the urban environment and public discourse

Project	City	Public discourse
Okhta Center	Saint Petersburg	"Economics - Preservation of Cultural Heritage"
Zaryadye Park	Moscow	“Government infrastructure - green areas in the center”
Church of St. Catherine	Ekaterinburg	"Temples - parks"
"Tuchkov brawler"	Saint Petersburg	“Expensive development with power functions - green areas in the center”
Concreting of river embankments Vologda	Vologda	"Landscaping - preserving greenery"
Construction of the fields of the Timiryazev Academy in Moscow	Moscow	"Redevelopment is a science"

Let's take a closer look at them.

1. The first selected project is the unrealized project for the construction of the Okhta Center complex (Gazprom City) in the center of St. Petersburg, which led to the collapse of the previous model of urban urban planning policy. This conflict was the result of a significant gap in the understanding of urban development between the authorities, business and society. The state company Gazprom, as the initiator of construction, obviously pursued the goal of consolidating its special economic role through architectural and spatial methods of symbolic politics, while public organizations were guided by cultural and aesthetic ideas about the preservation of the historical and cultural landscape. Their interests did not coincide at all. Even if we assume that the goals of the actors were convincingly argued on both sides, the lack of normal public discussion was the decisive critical factor that led to the largest eco-cultural conflict of recent years. The situation began to be resolved after the World Heritage Committee at UNESCO, under the influence of urban protection protests, asked Russia to develop and conduct an examination of alternative projects for the Okhta Center. The cancellation of construction took place under the influence of President D. A. Medvedev, who stated that the decision to build the Okhta Center was the construction project of the Church of St. Catherine in the park on Oktyabrskaya Square in Yekaterinburg; landscape and architectural planning on Tuchkovy Buyan in the center of St. Petersburg, etc. This material has not been summarized and published before. The authors evaluate the relevance of using these materials and supplement them with new data and new cases.

In the article, public discourse is the author’s evaluative category based on the study of the above-mentioned cases.

The Center should be accepted after completion of legal processes and consultations with UNESCO. The subsequent transfer of the administrative building of Gazprom to the periphery of the city, to Lakhta, became an important stage in the “braking” of the “growth machine” regime that had developed by the 2000s in St. Petersburg. The story of the construction of the Okhta Center became the subject of public discussion and an echo of the perception of innovation not only in St. Petersburg, but also in other regions.

2. Zaryadye Park is a huge area in the very heart of Moscow, east of Red Square. The idea of implementing a park in this space greatly influenced the urban image of Moscow, both in Russia and abroad. Until 2007, this territory was occupied by the Rossiya Hotel building, designed in the style of Soviet modernism. After long discussions about the possibilities of its reconstruction, a decision was made to demolish the hotel and build on this territory the Parliamentary Center (for the relocation of the Federal

Assembly of the Russian Federation), a hotel and business complex and a residential quarter. However, in 2012, following a survey among residents about a possible location for Hyde Park, a decision was made to create a new park area, and the construction of the Parliamentary Center was moved to the Mnevniki district. It is characteristic that both decisions did not provoke opposition from socially active groups of the population. The authorities recognized that the greatest value for this place is as a recreational and tourist site. Despite the regional competence of the project, its federal significance was emphasized by a joint statement by Russian Prime Minister V. Putin and Moscow Mayor S. Sobyanin. According to Putin, building a parliamentary center, a business zone with a hotel complex, as previously proposed, is ineffective, since this will create an additional burden on the center of Moscow. As a result, the direct intervention of the federal center resolved the dispute about the functional future of the territory.

3. The construction of the Church of St. Catherine in Yekaterinburg has become the most resonant transformation project outside of Moscow and St. Petersburg. The urgency of the issue was due to the fact that the construction of the temple was planned in the very center of the city. This case is also interesting because, under the influence of the public, the potential location for the construction of the temple was changed four times. Seven years of sluggish public resistance to the development gave way to significant pressure from regional and municipal authorities on the issue of building the cathedral and mass unauthorized rallies of the local population in 2019. The conflict quickly became known throughout the country, and Yekaterinburg became almost a symbol of the anti-religious agenda and the people's struggle for the "right" to the city." The situation was resolved after the intervention of Russian President V. Putin, who proposed finding a compromise and conducting a survey of the population. Based on the survey results, a certain consensus was reached among city actors.

4. The territory of Tuchkov Buyan in St. Petersburg is distinguished by a significant variety of projects that have arisen for the possible use of this space. If initially, after the demolition of the State Institute of Applied Chemistry located here, it was planned to build a residential and business quarter "Embankment of Europe", then in 2012, by the decision of the President of the Russian Federation V. Putin, it was decided to build a complex of Supreme Court buildings. As part of the campaign for the election of the governor of St. Petersburg in 2019, the acting governor A. Beglov initiated the decision to implement a park in this territory, taking into account numerous requests and demands of citizens. This decision was personally supported by the President of the Russian Federation, who changed his position on the issue of building the Supreme Court in this territory. However, in 2022, the issue of building a judicial quarter on this site again appeared on the media agenda. The only constant element during all the changes in redevelopment plans remained the construction of the Dance Academy building, publicly promised by President V. Putin to the artistic director of the theater B. Eifman

5. The project for concreting Vologda embankments was widely discussed on the regional and federal agenda. The developed plan involved the improvement of the embankments, but met fierce resistance from the local population. The principled position of the regional authorities, which called for "not to listen to anyone," led to repeated direct complaints from the local population to the President of the Russian Federation. However, in this case, even the intervention of the first person did not immediately slow down the process that had already begun. Currently, work has been partially suspended; the possibility of more rational landscaping, with maximum preservation of green areas, is being discussed.

6. The development of the territory belonging to the Russian State Agrarian University - Moscow Agricultural Academy named after K. A. Timiryazev (Timiryazev Academy) in the north of Moscow also became a large and significant project that required intervention at the federal level. In this case, we are talking about the implementation of a large residential construction project on the territory of the scientific testing grounds of the Timiryazev Academy. The situation caused discontent among the public and Academy employees, who turned to the president, who suggested leaving this territory alone. Initially, it was decided to maintain the existing construction plans, but under the influence of the public and federal authorities, the area intended for construction was reduced from 100 to 24 hectares.

In the final scale, we assessed the criteria for the social significance of projects for transforming the urban environment. For criteria 1.1 and 1.2, the authors introduced geographical parameters of location and scale, information about the functional status of the territory before the implementation of the project. Criterion 2.1 was designated as "Predominance of interests of actors at the beginning and end of the project" and differentiated depending on which of the actors was the largest beneficiary at the beginning of the project and at the end of the project. Criterion 2.2, which assesses the significance of the project for different levels of government, is built on a hierarchical principle - from the highest level of intervention (international, federal) to the lowest (regional, municipal). The significance of the transformation project is classified on a scale of "high - low". Criterion 2.3 focuses on the breadth of publications about the project and reflects the extent to which the discourse has gone beyond the regional (city) agenda. For assessment, a scale similar to

criterion 2.2 was used. Criterion 3.1 analyzes the change in the functional purpose of the territory during the project and allows us to see how the essential direction of the transformation project changes. Criterion 3.2, using the phase identification method, evaluates the number of changes in the concept of the transformation project and its functional content in the process of agreement by all actors. Finally, criterion 3.3 demonstrates whether a decision was made to move the project (or its function) to another location, which indicates the type of resolution of the conflict around the case and reflects the special social significance of the transformation project. A more detailed analysis of the substantive effectiveness of the cases, the role and participation of actors in socially significant projects is also presented additionally.

The results of the analysis of socially significant projects for transforming the urban environment demonstrate the similarity of implementation scenarios in different Russian cities. As a rule, cases become publicly significant due to their location and the gradual increase in public attention to the project. It is worth noting that all transformation projects that required the intervention of federal authorities were resolved in various forms of consensus among actors. All selected projects required the personal participation of the President of the Russian Federation, and in the case of the Okhta Center project, even the intervention of a global actor - UNESCO. As a result, none of the projects presented here were implemented in the original form. Moreover, four of the six projects considered were moved and implemented in a completely new and less conflict location (for example, the construction of a temple in Yekaterinburg was moved to the territory of a former instrument-making plant; the Okhta Center was built on the periphery of the city, in Lakhta). Such transfers largely correspond to public outcry in the media and are accompanied by a change in the concepts of projects in the original territory.

It is obvious that the cases we have chosen demonstrate a more complex system of relationships between actors. According to E.V. Tykanova and A.M. Khokhlova, the same St. Petersburg of the 2000s was characterized by a growth regime due to an obvious tactical compromise between the interests of the authorities and large construction business (according to V. Ya. Gelman - the regime of “state-predator." Stone points out that such a situation can, in principle, arise only if the authorities and business have the ability to mobilize capital. As soon as these opportunities become limited, the ground arises for the formation of a new regime. In the case of active influence of society, the formation of progressive regime of the middle class. In the case of passive influence of all actors - “status quo”. According to Clarence Stone, in order to change the regime to a progressive one, the existence of an “active middle class” (active civil society) with a significant amount of free time is necessary. General cooperative agenda For society, as a rule, the topic of ecology, anti-militarist issues, and the protection of cultural heritage becomes a topic.

In our opinion, in most cases, the closest thing to the current situation is the progressive regime of the middle class, which is formed when society begins to seriously oppose projects arising in the field of “growth” strategies. The existence of such a regime largely explains the final abandonment of such symbolic projects for the city’s image as the Okhta Center, the Church of St. Catherine or the European embankment on Tuchkovy Buyan. However, in the initial phases of the implementation of these socially significant projects, the situation was more close to the growth regime due to obvious coalitions of government and business. Additionally, it should be mentioned that the most important structural factor in the formation of growth coalitions is recovery economic growth; in Russia it was widespread in the first half - mid-2000s. In turn, “growth machines” (coalitions of government and business) suppress other actors, deprive them of their voice, and society is forced to look for ways to consolidate with various political groups, parties, and urban protection organizations in order to influence the situation. This state of affairs is extremely typical for the cases of the temple in Yekaterinburg, Okhta Center, and Tuchkov Buyan in the initial stages of their implementation.

The chosen methodology allows us to take into account the different levels of involvement of business, the public and the administration in various socially significant projects. As we indicated above, our study uses the theory of urban regimes as an analytical tool that allows us to see the ability of various actors to work together to produce a socially significant result in space. The methodological approaches we have chosen are relevant, since they differentiate in as much detail as possible the state of projects for transforming the urban environment, and also allow us to visually see different local options for transitions from one urban regime to another. The local transformation of the interaction of actors triggers the transformation of the urban regime as a whole. As we have already noted, certain territories may have their own system of interactions between actors, which may differ from the citywide management system.

As follows from the materials, all significant projects for transforming the urban environment that were considered were initiated either by business or government. Almost all of them initially had a business/commercial goal (one had a religious-business goal), which was abandoned in the process of interaction between the actors in favor of a new socially significant one. An exception may be the case of the Timiryazev Academy development project, where the scale of the project was reduced in favor of

preserving part of the territory for existing functions. According to the theory of urban regimes, the initial phase of all projects obviously took place in the realities of local urban growth regimes with the predominance of the interests of established coalitions of business and government. The increase in the role of public activism in projects that followed at the next stages and the change in goal setting in all projects under its influence allows us to assert that during the implementation of the above criteria, a change in the local urban regime occurred. Since the composition of the coalitions influencing projects expanded at the expense of the social actor and it was his interests that became governing in the final stage of all projects, we can claim that in five cases we observed a change in local urban regimes from "growth" to "progressive", since the realized interests of society there were associated not with conservation, but with development in the interests of the urban middle class, and in the case of the Timiryazev Academy, the regime transformed more towards the "status quo" regime. For the urban environment in total, the transition to a "progressive" regime leads to an increase in the number of public spaces in the city in relation to commercial and administrative spaces, which was noticed in the 2010s, which, in our opinion, is an important indicator of the transformation of the urban regime as a whole.

However, changes in the interests of actors do not always occur in one direction. As we noted above, in the case of the Timiryazev Academy, public opinion was taken into account: in most of the territory the existing function was preserved; however, on a smaller part, business interests still prevailed. On the other hand, the implementation of a park on Tuchkovy Buyan was de facto officially authorized in the public interest, but taking into account the interests of the federal government. Therefore, it is important to note that the transition to a middle class regime does not necessarily mean a complete transition of all actors to the position of public opinion. Consensus can be found taking into account the interests of society, but also taking into account the interests of government and business. However, the fundamental difference between the "progressive" regime and the "growth" regime will be the fact that the situation can no longer be unambiguously resolved in anyone's favor without taking into account and the influence of public position.

A number of fundamental, analytical and exploratory scientific works by domestic and foreign authors, based on various, often incompatible and diametrically opposed theoretical and methodological approaches, are devoted to the study of the sources and vectors of transformation of the modern system of international relations. At the same time, most researchers recognize, or at least do not deny, the dominant influence on the state and processes of change in the existing and institutionalized world order of the triad of immanently contradictory megatrends of globalization - de-globalization, integration - disintegration, democratization - de-democratization. The structural and substantive characteristics of alternatives to these megatrends make it possible to integrate other vectors (trends) of global development (active introduction and use of information technologies, the formation of a digital society and digital culture, chaotization of the consequences of uncontrolled migration flows, etc.), significantly expanding and complementing the realities of the first third of the 21st century

Within the framework of this article, the current world order will be considered as a transformation of the system of international relations. At the same time, the authors, in order to clearly argue their position on the issues of the place of the Russian Federation and its role in the restructuring of the modern architecture of international relations, rely on the conceptual provisions of M.M. Lebedeva that "the political organization of the world is understood as a structure formed by three main levels, namely:

1) Westphalian political system;

2) a system of international (interstate) relations, including the configuration of the leading states of the world, as well as other structures formed by states (international organizations, integration associations, club formats of interaction, etc.);

3) the totality of political systems of various states of the world. At the same time, all three levels experience mutual influence from each other, which in modern conditions, with their simultaneous transformation, forms the effect of a "perfect storm."

The capabilities of the selected system analysis are complemented by the research tools of the realistic approach in international relations, which makes it possible to specify the factors and conditions and the direction of their transformation.

The work uses the ideas and theoretical constructs of a number of methodological approaches - conflictology, riskology, globalization and regionalization to characterize the qualitative and quantitative parameters of the main actors in the restructuring of the system of international relations. The authors consciously tried to overcome ideological bias and the limited potential of certain concepts when analyzing specific facts, mechanisms, conditions and factors, formulating and defending national-state and other interests in the political space of the global world from a historical perspective.

The analysis of the main directions and priorities of Russian foreign policy in accordance with the "Concept of Foreign Policy of the Russian Federation" adopted in 2023 is based on a number of provisions of the civilizational approach. It is important to emphasize that the actualization of the civilizational "view" of the modern world presupposes, on the one hand, overcoming the Western-centric "emphasis" on understanding and

studying civilizations. On the other hand, a rethinking of two largely dominant alternative cultural and civilizational versions, one of which "believed that the organizing principle of the world order was the opposition of a unitary and universal human civilization in its potential," and the other "started from the coexistence of multiple civilizational projects and assumed that the foundations of a new world order will be developed, and its prospects will become clearer directly in the process of intercivilizational interaction."

Justifying the place of the Russian Federation in the conditions of transformation of the modern world order, the authors of the article proceed from the recognition of more than a thousand years of experience in the existence of independent Russian statehood, "they define the special position of Russia as a distinctive state-civilization, a vast Eurasian and Euro-Pacific power that has united the Russian people and other peoples, constituting the cultural and civilizational community of the Russian world." At the same time, one should take into account the debatable nature of points of view in the scientific community when stating the basic characteristics of Russian civilization in comparison with other civilizational formations, which V.G. quite rightly focused on in his two-volume monograph, published in 2022. Khoros.

The empirical basis for this work was the regulatory documents of the Russian Federation; results of studies conducted by leading centers such as: VTsIOM, FOM, Levada Center*. A significant role in the selection of the evidence base to substantiate the author's positions was played by the results of theoretical and empirical research, and scenario approaches outlined in the reports of the Valdai International Discussion Club.

The approval in March 2023 of the "Concept of Foreign Policy of the Russian Federation" marked, in our opinion, a new starting point in the reasonable articulation and implementation of national interests and strategic goals of Russia in the context of the increasing pace of transformation of the existing world order in general and the system of international relations in particular. "The unbalanced model of global development, which for centuries ensured the accelerated economic growth of colonial powers through the appropriation of the resources of dependent territories and states in Asia, Africa and the Western Hemisphere, is irreversibly becoming a thing of the past. The sovereignty is strengthened and the competitive capabilities of non-Western world powers and regional leading countries are increasing."

Such an effective position of Russia on restructuring the system of international relations is largely due to the fact that neither the country's leadership nor the majority of citizens currently "have illusions" regarding the possibility of positive cooperation between the Russian Federation and the countries of the Western world [6; 25]. In fact, Russia was one of the international actors that initiated the process of purposeful consolidation of non-Western countries to form multipolarity and overcome the hegemony of a few led by the United States. It should be recognized that the acquisition of foreign policy autonomy and the ability to freely plan one's own regional and global projects took a fairly long period of painful rethinking and overcoming the consequences of pseudo-liberal reforms (socio-economic, political-legal, military, etc.) of the 90s. last century. At the same time, limited resources, on the one hand, and the inexpediency of the policy of isolationism, to which a number of unfriendly countries are pushing Russia, on the other hand, objectively make it possible to pursue a multi-vector, pragmatic foreign policy course based on the principles of equal international cooperation to solve common problems and defend mutually beneficial interests.

Thus, the functional necessity of having a superpower in the structure of the currently institutionalized world order is lost. The unconditional hegemony of one superpower in the person of the United States as a consequence of the cessation of the existence of the USSR and the policy of maintaining a "balance of power" between the two poles of gravity showed significant signs of devaluation due to the destructive practices of the uncontested imposition of the liberal model of globalization, ideologically justified by the concept of the "end of history." The ideological and institutional consolidation of a "unipolar world," determined directly by the interests of the United States and its closest allies, primarily NATO, at the end of the 20th century, negated the real sovereignty of the Russian state. As noted in the annual report of the Valdai Club, "Russia became the first major power that, guided by its own ideas about security and justice, decided to abandon the benefits of "global peace" created by the only superpower.

The independent successful economic and financial policies of China, the strengthening of the military-political sphere of the Russian Federation, the strengthening of regionalization processes in the non-European part of the world with the institutionalization of new economic, intergovernmental, military-strategic blocs and structures allow us to speak about an increasing tendency, on the one hand, to the loss of positions by supporters of a unipolar world, and on the other hand, to identifying problematic aspects of Russia as a subject of international relations. At the same time, a number of experts point to the asymmetry of the emerging relations between the Russian Federation and the PRC, which could lead to Russia's potential dependence on China and the deprivation of our country's freedom of action, at least in the field of international cooperation. In this context, it is the implementation of the multi-vector foreign policy of

the Russian Federation, which consists, among other things, in the development of multilateral interstate relations, especially within the framework of the Eurasian structures being created, that will avoid mutual distrust and mistakes.

From the authors' point of view, it is difficult to ignore the fact that, in conditions of concentrating on solving internal socio-economic and political problems, the PRC and the Russian Federation believed that US dominance was a temporary phenomenon with equal cooperation possible in the future. However, the United States did not plan a dialogue with these countries as independent entities. It was this circumstance that largely brought China and Russia closer at the beginning of the 21st century. Moreover, none of these countries, in their domestic and foreign policies, claims to recognize the universality of their value, economic and political systems for the world community. Rather, on the contrary, they focus on their historical uniqueness and uniqueness.

Taking into account the civilizational specifics of individual states and their unions is reflected in the recognition of Russia itself as a distinctive state-civilization, on whose territory live the peoples who form the community of the Russian world. The use of a civilizational approach in analyzing the transformation of the modern world order expands the possibilities of political science tools to consider the interactions of states and societies as an organic / intermittent / conflict process of the development of distinctive national cultures. At the same time, the current structure of the world order is based on the parameters of European civilization, which practically does not recognize (or rather ignores) the achievements of other civilizations, which leads to a "clash of civilizations."

Consequently, one of the directions for analyzing the transformation of the system of international relations is objectively rethinking the mechanisms and forms of combining previously incompatible civilizations that claim to have and implement political content and form. In philosophical-historical and then political science discourse, until recently, the prevailing position was that the incompatibility of value systems is the main reason for the difference between one civilization and another. In this sense, the practice of the existence of China as a state-civilization and its vectors of interaction with Russia are aimed at reproducing and defending the civilizational foundations of the non-Western world in the conditions of the established global civilization.

The civilizational component allows us to take a different look at the processes of exporting democracy, democratic transits to other countries and regions, which the United States, together with its closest allies in NATO and the EU, are implementing through various forms of expansion. It was they who took upon themselves the "historical mission" of spreading and rooting the values of democracy and democratic transit in their version of interpretations and indicative indicators in other states and regions with completely different civilizational codes of organizing life activities, including political ones.

Of no less importance for understanding the vectors of transformation of the system of international relations is the recognition of the limits of the impact of globalization on state sovereignty. It has become a practice that members of integration associations voluntarily renounce part of their sovereignty, delegating it to the supranational level. However, this does not mean that in a globalizing world state sovereignty does not exist, thereby allowing other subjects of international relations (states, regional and global organizations) to interfere in the internal affairs of states under one pretext or another. From our point of view, one of the most important conditions for the existence of the Russian Federation as a sovereign state is the preservation of its territorial and constitutional unity.

Earlier in this article, it was emphasized that the United States and its closest allies do not give up attempts to interfere in the affairs of Russia as a sovereign state, exerting information, economic (sanctions) and other types of pressure on the institutions of the state and civil society, including on individual citizens. Back in 2017, the Temporary Commission of the Federation Council to protect state sovereignty and prevent interference in the internal affairs of the Russian Federation was created and is actively working. The main tasks of the commission are to monitor external threats to Russian sovereignty, including attempts to influence the foundations of the constitutional system, the foreign and domestic policies of the Russian Federation, its territorial integrity, the composition of public authorities, and to develop recommendations for preventing real and potential threats by improving national legislation.

At the same time, even in the current world order, there is a positive practice of cooperation between countries that have full sovereignty in the growing BRICS organization. It should be emphasized that this organization, in a fairly short time, has evolved from an artificial construct created by a group of countries and called BRICS, to the development of a fundamental criterion for full inclusion in its structures - the ability to pursue a completely independent policy. At the same time, this criterion is not simply declared, but is supported by the economic potential of each country. Thus, participation in BRICS is a marker of participation in a system beyond Western domination. The authors focus on the fact that in this case, almost all countries included in the BRICS are under pressure from the Western alliance. In this context, the viability of the organization is based not on opposition and

confrontation with other states, but on the ability to minimize risks from interaction with them.

One of the resources to counter the transformation of a unipolar world to a multipolar one is the use of the technology of "geopolitics of perception," defined as the dominant discourse "developed by the dominant powers and imposed on the rest of the world as an idea of the essence and significance of world-political processes, as well as one's own place in the world." Western countries formulate and impose their own interpretation of the development of the world system, not allowing for a different vision of the situation, other trends that are "maturing" and objectified in the 21st century. An example of the use of "geopolitics of perception" is the Russophobic rhetoric caused by the expansion of the EU and NATO to the East, to the borders with Russia.

Summarizing the political science analysis of the vectors and factors of transformation of the modern system of international relations, the question logically arises about the place and role of Russia in the conditions of chaotic activity of institutional / non-institutional entities, turbulence and inconsistency of the political organization of the world. Currently, several variants of forecast scenarios for the inclusion of the Russian Federation in the world order, characterized by a high level of conflict and unpredictability, dominate: - "dissolution" of Russians in the demographic structure of the global community with a narrowing of the territorial-state framework and loss of subjectivity in the dominant system of international relations, namely:

– civilizational regionalization of Russia within the framework of a system of limited influence on individual countries that were previously part of the structure of the USSR;

– etatization of all intrasocial relations with the accelerated institutionalization of a self-sufficient "closed society";

– liberal, implying the final consolidation of Western values and standards of living with the loss of the sovereignty of the Russian state;

– East-centric, based on the dominance of China and the subordinate position of Russia as a civilization state;

– independent (restrainedly optimistic), characterizing Russia as one of the sovereign actors in the emerging multipolar world.

At the same time, Russia's foreign policy and its place in the transforming system largely depend on mutual understanding with friendly and unfriendly countries, including the relationship between two basic vectors – values and interests. Russia proceeds from the fact that the democratization of social life and government in various countries acts as an internal evolutionary process, taking into account historical, civilizational characteristics and socio-economic priorities.

Conclusion

The materials obtained allow us to draw informed conclusions about the progress of the process and the results of the change in local urban regimes. It is shown that in five studied cases we observed a transition of local urban regimes from "growth" to "progressive", and in one - from "growth" to a greater extent towards the "status quo" regime (the case of the Timiryazev Academy). The results of the applied research confirm the correctness of the hypothesis put forward: all the identified criteria for the social significance of projects for transforming the urban environment were in a significant differentiating mutual influence with changes in the parameters of urban regimes. The main "cut-off" criterion for intervention by federal authorities, used in the selection of the cases under study, together with the criterion of the subsequent radical change in the concept of the project in the conditions of the peculiarities of the Russian political system, allows us to assume that the studied cases, although they describe only local changes in urban regimes, nevertheless become potentially "precedent ", at least for the cities studied. A more reasonable extrapolation of conclusions about local regime change to cities as a whole, however, requires additional research. Here we have described to a greater extent the mechanisms of such a change and the participation in it of socially significant projects for transforming the urban environment.

Based on the results of the study of such mechanisms, the authors identified the following principles of mutual influence of socially significant transformation projects and urban regimes in the Russian Federation, namely:

1. **The principle of competitive public interaction of all types of actors.**The comprehensive, effective interest in the project on the part of all types of actors, which predetermines the social significance of projects, is common to all studied cases of change in the local urban regime, regardless of the type of such change. Transformation becomes socially significant as a result of interaction, accompanied by the presence of conflicting clashes between actors.

2. **The principle of changing or moving a project as a spatial way of resolving conflict.**Such a change under the influence of public activism is the most important reaction, demonstrating high social significance, and indicates a local transformation of the urban regime. The idea of relocating the project with the transfer of its original function to another territory increases the significance even more (relocating the Okhta Center, the temple in Yekaterinburg, the complex of buildings of the Supreme Court, the Parliamentary Center).

The patterns of such mutual influence identified in the research materials and subject to verification on a larger sample include the following:

1. The prevailing shift from realizing the interests of government and business to the benefit of society. It has been recorded that during the implementation of transformation projects there is a change in the influence of actors. In most cases, social significance was closely related not simply to the clash of interests of actors, but to the predominance of the interests of society over the interests of other actors. If in the early stages the influence of government and business is high, then during the implementation of the project the role of society grows noticeably. According to the authors, this allows us to talk about the gradual formation of a "progressive middle class regime."

2. The involvement of paternalistic instruments de facto allows reaching consensus. The intervention of the federal government is a characteristic method for Russian practice in resolving situations around socially significant transformation projects. The participation of the president or federal institutions in resolving issues around transformation projects speaks of crisis nodes in the relationships of actors in cities, and also indicates insurmountable public pressure. Ultimately, federal intervention leads to a decision based on public opinion.

It should be noted that the identified principles and patterns significantly influence changes in the urban environment. Thus, thanks to changes and transfers of projects, territories appear where the original redevelopment plan could not be implemented, the number of free spaces and green areas increases instead of the original development projects (Zaryadye Park, Truda Square in Yekaterinburg, park on Tuchkov Buyan). The relocation of projects opens up the potential for the development of new urban peripheral territories, a previously untapped urban environment.

Selected socially significant projects for transforming the urban environment are fully indicators of changes in local urban regimes, as they allow us to see the clash of interests of actors and its results at the local level, using a "game of scale." In the cases we have chosen, the "growth" regime is gradually being replaced by elements of the "progressive" middle class regime. It should be emphasized that in connection with the described cases we should not talk about different regimes in different cities, but about local regimes formed by specific projects in the local environment during a certain period. These conditions are studied in detail and briefly described in the work for each case. Such conditions can arise at a certain period in any large Russian city, and then we can expect results of transformation of space similar to those described. Currently, there is a significant local transformation of the dominant urban regimes in Russian cities; certain parameters of their mutual influence with the transformation of urban space are described by the authors in this article.

The Foreign Policy Concept of the Russian Federation clearly ranks Russia's regional priorities in the context of the turbulence of modern world political processes: the near abroad, the Arctic, the Eurasian continent, China, India, the Asia-Pacific region, the Islamic world, Africa, Latin America and the Caribbean, the European region, the USA and other Anglo-Saxon states, Antarctica. At the same time, it is necessary to conclude that there is a high level of dynamism of change and often unpredictability in the development of international relations. Thus, from the authors' point of view, the modern world order as a whole represents only a relatively stable state of the international system, limited in spatial and temporal dimensions, characterized by the effective-functional specificity of state / non-state, institutional / non-institutional actors with recognized / limitedly recognized rules of behavior on international arena.

At the same time, basic components and their characteristics are identified, subject to transformation and ultimately determining the structure and nature of the world order in a specific period of world history. Modern transformation processes of the world order, from our point of view, appear, on the one hand, to be logical, taking the completed form of the "end" of the bipolar confrontation between the two powers and based on class, ideological differences between the systems of the USSR - USA, socialism - capitalism. On the other hand, despite the more than thirty-year period of cessation of the existence of the USSR, the Russian Federation, as the legal successor of the Soviet state, is still perceived by a certain part of the ruling elites and the population in the "image of an enemy" who was defeated in the Cold War, but claims to establish the principles of a new world order in coordinates of multipolarity based on the community of non-Western countries.

The established crisis system of international relations at the beginning of the 21st century. determined by a sharp aggravation and confrontation between Russia and NATO; infringement of Russia's rights in European regional structures and organizations (Council of Europe and the Parliamentary Assembly of the Council of Europe); aggravation of positions and relationships between the permanent members of the UN Security Council, etc. At the same time, the principles of international law have largely been transformed into a symbolic policy carried out according to certain rules established by the only global superpower, the United States.

Currently, from our point of view, only a limited number of countries and regional organizations are included in the process of transforming the world order from one polarity to a multipolarity, which characterizes a positive trend in the system of restructuring international relations led by the Russian Federation, China, and other BRICS countries. However, serious efforts are being made by the United States and its closest allies to preserve or slightly

modify the unipolar world, with these countries preserving their existing global privileges. Hence the "unwinding" of the flywheel of conflict through confrontations along the "perimeter" with Russia, without hiding the desire and goal of its not just weakening, but defeat and destruction as a sovereign subject of international relations.

Consequently, the current stage of the political transformation of the world will most likely take a long time, and Russia, China, as well as other non-Western countries will have to defend their right to sovereignty and multi-vector cooperation in the context of the "resistance" of Western countries to the world's movement towards multipolarity. Inevitably, a struggle arises for the development and implementation of a model for reforming the UN, consolidating the status of the new members of the Security Council as today the only legitimate international institution for coordinating the main directions in the system of international relations. At the same time, Russia as a state of civilization has internal (which need to be strengthened) and external resources (which need to be expanded) to function as one of the leading centers of gravity in a multipolar world.

References:

1. Ageeva, A. F. (2019). Analysis of approaches to assessing socially significant investment projects in the Russian economy. *Bulletin of the Academy*, 2, 40–51.
2. Bakharev, V. V., & Demina, V. A. (2019). Participation of network communities in the formation of social capital in the process of participatory design of the architectural and landscape space of the city. *Regionalology*, 2 (107), 354–381.
3. Bederson, V. D., Zhelnina, A. A., Zaporozhets, O. N., Minaeva, E. Yu., Semenov, A. V., Tykanova, E. V., Khokhlova, A. M., Chernysheva , L. A., & Shevtsova, I. K. (2021). *Cities of diverging streets: trajectories of development of urban conflicts in Russia.* M.; SPb.: FNISC RAS.
4. Borisova, N. V., Sulimov, K. A., Kovina, O. V. (2011). Coalitions in the cities of the Kama region: factors in the formation and preservation of urban political regimes. Bulletin of Perm University. Series: Political Science, 1, 5–14.
5. Galustov, K. A., & Khodachek, I. A. (2021). Beyond Statistics: A Qualitative Study of the Transformation of the Primary Economy in the Post-Soviet Russian Arctic. *Arctic and North*, 42, 60–80. https://doi.org/10.37482/issn2221-2698.2021.42.60
6. Zamyatina, N. Yu. (2022). *Models of political space. In: Political Geography: Modern Russian School: Reader*. (pp.512-527). M.: Aspect Press.
7. Zakharova, E. E. (2017). Public spaces as factors in the sociocultural development of local territories. *Bulletin of Culture and Arts*, 2 (50), 122–127.
8. Ivanova, V. V., & Zykova, M. A. (2017). Urban architecture as a way of constructing and deconstructing the social practices of citizens. *Bulletin of NSU. Series: Social and Economic Sciences*, 2, 150–159.
9. Klyukanova, L. G. (2019). Sustainable cities: integrated development of urban areas and legal mechanisms to ensure the realization of citizens' rights to a favorable environment. *Eurasian Law Journal*, 1, 213–219.
10. Koroleva, M. N., & Chernova, M. A. (2017). Tactics for implementing urban projects in the context of modern management practices and legislation. *Urban Research and Practice*, 3, 28–41.
11. Koroleva, M. N., & Chernova, M. A. (2018). Urban activism: management practices as a resource and barrier to the development of urban projects. *Sociological Research*, 9(9), 93–101.
12. Petrov, A. A. (2018). Analysis of priority factors for the development of the construction sector in Russia and identification of possible directions for neutralizing influences. *Current problems of economics and management*, 2 (18), 56–62.
13. Pustovoit, Yu. A. (2018). "Land" and "freedom": urban regimes and protest communities in Siberian cities. *Power and Elites*, 5, 295–330.
14. Samataryova, K. A. (2017). Methodology for studying the urban political regime. *Political Conceptology*, 4, 252–256.
15. Ter-Voskanyan, O. Sh. (2018). Patterns of formation of the pedestrian environment in the city. *Academia. Architecture and Construction*, 23(3), 94–99.
16. Tkachenko, S. B. (2019). Zaryadye development concepts: from hotel to park. *News from universities. Investments. Construction. Real Estate*, 1(28), 196–213.

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ISRA (India)		1.344				3.117	4.971		6.317			
ISI (Dubai, UAE)	0.307	0.829							1.582			
GIF (Australia)	0.356	0.453	0.564									
SIS (USA)	0.438	0.912										
РИНЦ (Russia)		0.179	0.224	0.207	0.156	0.126		3.939	0.671	0.177		
ESJI (KZ)		1.042	1.950	3.860	4.102	6.015	8.716	8.997	9.035	8.771	8.502	
SJIF (Morocco)		2.031				5.667			7.184	6.296		
ICV (Poland)		6.630										
PIF (India)		1.619	1.940									
IBI (India)			4.260									
OAJI (USA)						0.350						

Deadlines

	Steps of publication	Deadlines	
		min	max
1	Article delivered	-	
2	Plagiarism check	1 hour	2 hour
3	Review	1 day	30 days
4	Payment complete	-	
5	Publication of the article	1 day	5 days
	publication of the journal	30th of each month	
6	doi registration	before publication	
7	Publication of the journal	1 day	2 days
8	Shipping journals to authors	3 days	7 days
9	Database registration	5 days	6 months

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	GIF (Australia)	= **0.564**	**ESJI** (KZ)	= **8.771**	**IBI** (India)	= **4.260**
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Signed in print: 29.02.2024. Size 60x84 1/8

«Theoretical & Applied Science» (USA, Sweden, KZ)
Scientific publication. The circulation is 90 copies.
http://T-Science.org E-mail: **T-Science@mail.ru**

Printed «Theoretical & Applied Science»

Philadelphia, USA

Clarivate Analytics indexed