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AGRICULTURAL SCIENCES

THE EFFECT OF SELECTION AND BREEDING POTENTIAL OF DAIRY CATTLE IN THE MURMANSK REGION

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РЕАЛИЗАЦИЯ СЕЛЕКЦИОННО-ПЛЕМЕННОГО ПОТЕНЦИАЛА МОЛОЧНОЙ ПРОДУКТИВНОСТИ КРУПНОГО РОГАТОГО СКОТА В УСЛОВИЯХ МУРМАНСКОЙ ОБЛАСТИ

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<https://doi.org/10.5281/zenodo.17608946>*

Abstract

The Holstein breed is widespread in the world. Regardless of climate condition, cows of this breed are capable of demonstrating high productivity on farms, including in the Far North, specifically in the Murmansk region. The animals' record achievements are the result not only of selection and breeding work within the herd but also of a well-organized housing and feeding system. In the Murmansk region, cow Argentina 1244 achieved a record milk yield of 19,000 kg.

Аннотация

Голштинская порода имеет широкое распространение в мире. Независимо от климатических условий животные этой породы способны показывать высокие продуктивные качества в хозяйствах, в том числе в условиях Крайнего Севера, а именно в Мурманской области. Рекордные достижения животных являются итогом не только длительной селекционной и племенной работы в стаде, но и результатом правильной организации системы содержания и кормления животных. В Мурманской области коровой Аргентина 1244 достигнут рекорд 19 тыс.кг молока.

Keywords: Holstein breed, milk productivity, Murmansk region, record

Ключевые слова: голштинская порода, молочная продуктивность, Мурманская область, рекорд

В настоящее время наиболее используемой и высокопродуктивной считается голштинская порода. Согласно данным Всемирной голштинской ассоциации (WHFF) численность голштинской породы в мире составляет почти 70% от общей численности молочного поголовья. Продуктивность этой породы в разных странах колеблется от 4560 кг до 12775 кг за 305 дней лактации [1, р. 1]. В России данная порода также имеет широкое распространение благодаря своим качествам, составляя до 72% поголовья [2, р.5]. Средняя продуктивность этих животных в 2024 году в РФ составила – 10082 кг за 305 дней лактации, что является максимальным по сравнению с другими породами [2, р.7].

Естественно, что регионы РФ, расположенные в более низких широтах, с умеренно-теплым климатом, имеют больше возможностей для создания оптимальных условий для высокопродуктивных животных. Это и более комфортные микроклиматические условия, и лучше развитая собственная

кормовая база. Несмотря на это в Мурманской области животноводы и селекционеры за счет оптимизации содержания и кормления, а также хорошей селекционной работы, достигли существенных результатов.

Если мы обратим внимание на динамику изменения молочной продуктивности в Мурманской области по сравнению с данными по стране и Север-Западному округу (рис. 1), то можно отметить, что до 2013 года средняя продуктивность коров на сельскохозяйственных предприятиях региона была существенно выше (почти в 2 раза). К сожалению, в 2014-2016 годах в хозяйствах наступил финансовый кризис, обусловленный как сменой собственников и руководителей предприятий, так и изменениями в законодательстве и финансовых обязательствах, которые повлияли на объемы производства молока в регионе. В то же время сейчас мы наблюдаем постепенную стабилизацию и улучшение ситуации в производстве молока в Мурманской области.

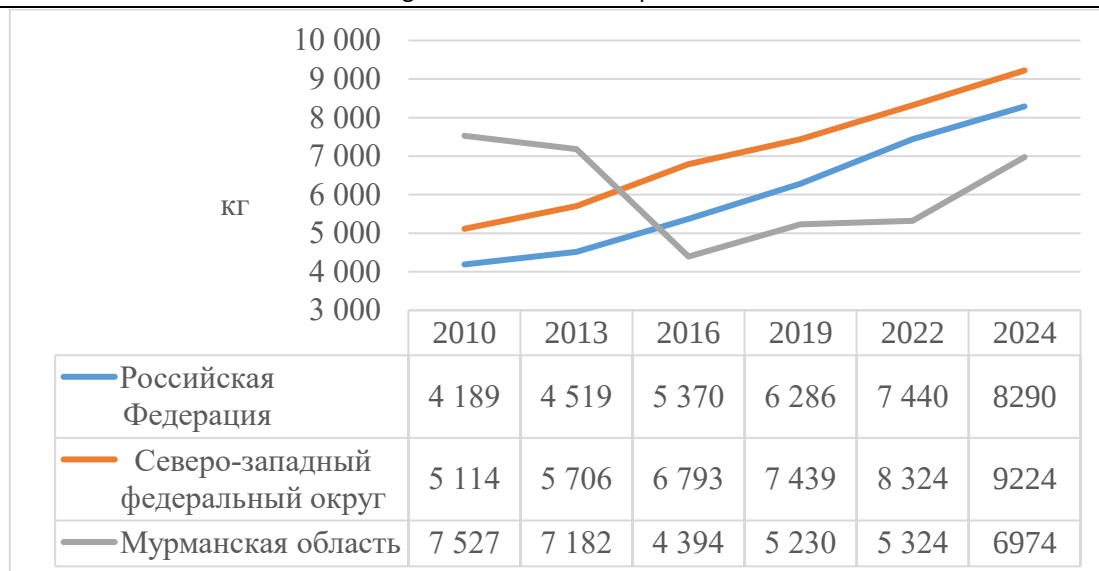


Рис.1 - Динамика молочной продуктивности в Российской Федерации и Мурманской области (на 1 фуражную корову)

Ниже представлен график изменения продуктивности животных (рис.2) в наиболее передовом в Мурманской области хозяйстве – ООО «Полярная звезда». Из графика отлично видно, что до кризиса средняя продуктивность животных достигала 10 и более тыс. кг молока за 305 дней лактации. К сожалению, проблемы с кормами и финансовые сложности вызвали резкое сокращение продуктивности в 2

раза, что в дальнейшем привело и к сокращению поголовья. Однако, несмотря на это хозяйство активно восстанавливает свой высокий статус. Так в 2022 году, согласно бонитировке, средняя продуктивность по стаду составила уже 11 тыс. кг молока, а по третьей лактации - 12 тыс. кг молока.

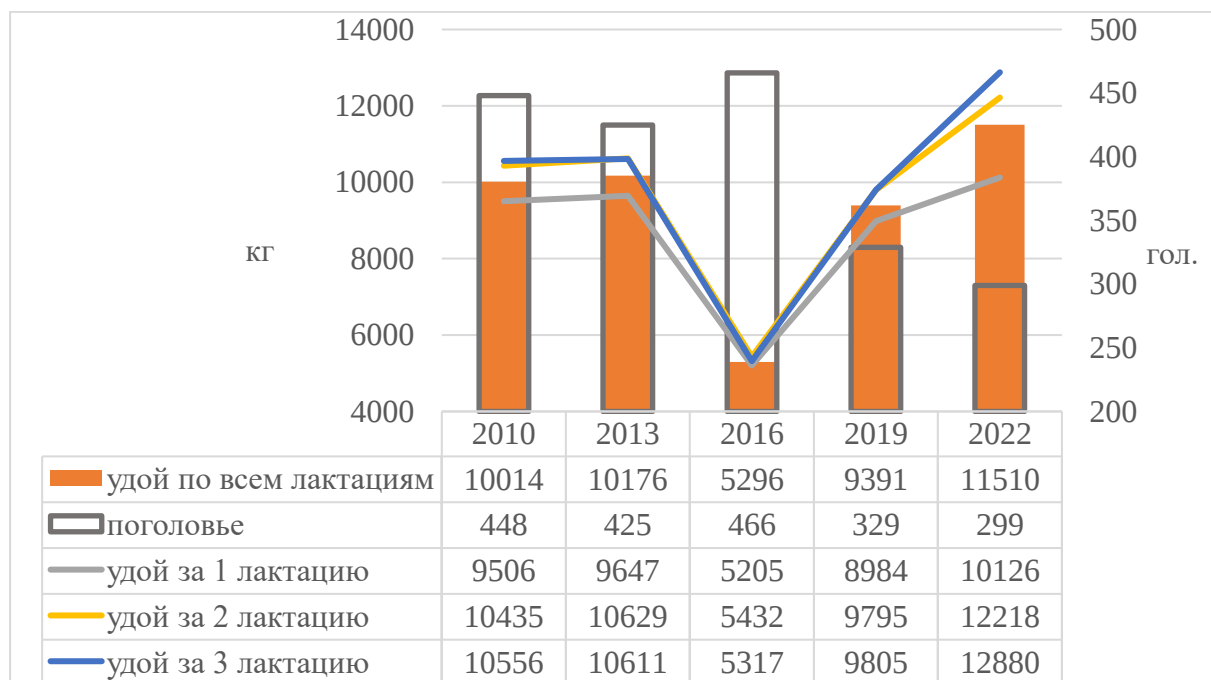


Рис.2 - Продуктивность коров в ООО «Полярная звезда» за 305 дней лактации (данные бонитировки)

Для сравнения приведены лучшие в Российской Федерации на 2024 год племенные хозяйства (таблица 1), специализирующиеся по голштинской породе. На первом месте в настоящее время находится хозяйство ООО СП «Чапаевское» (Ставропольский край). Вторым в этом году стало хозяй-

ство из Краснодарского края – АО «Родина». Хозяйства Ленинградской области длительное время сохраняют свои лидирующие позиции. Особенно племзаводы «Гомонтово» и «Рабицы». Средняя продуктивность их животных составляет 14-15 тыс. кг молока.

Таблица 1

Лучшие хозяйства по голштинской породе в Российской Федерации в 2024 году				
Хозяйство	Регион	Удой за 305 дней лактации, кг	Жир, %	Белок, %
ООО СП «Чапаевское»	Ставропольский край	16026	3,7	3,4
АО «Родина»	Краснодарский край	15798	3,69	3,37
АО «ПЗ «Гомонтово»	Ленинградская область	15215	3,61	3,33

К сожалению, в настоящее время ООО «Полярная звезда» уступает данным хозяйствам по фактической продуктивности, хотя потенциал животных за период более двадцати лет селекционной работы в стаде достаточен для успешной конкуренции с лучшими животными страны.

Если смотреть в целом по племенным хозяйствам Российской Федерации [2, р.46], то в среднем по России продуктивность молочного скота составляет 9204 кг молока (табл.2). В 18 областях средняя продуктивность по всем породам была более 10

тыс.кг молока. На первом месте находится Пензенская область (Приволжский федеральный округ). Мурманская область в настоящее время находится на 60-м месте, хотя в 2010-2011 годах она находилась в числе лидеров [3, р.92]. По голштинской породе в 30 регионах продуктивность была выше 10 тыс.кг молока, в двух областях (Саратовской области и Ставропольском крае) – выше 12 тыс.кг молока. Мурманская область в настоящее время находится на 35-м месте по продуктивности голштинской породы.

Таблица 2

Рейтинг регионов Российской Федерации по молочной продуктивности в племенных хозяйствах

Рейтинг	Регион	Удой за 305 дней лактации, кг	% жира	% белка
По всем породам				
-	Российская Федерация	9204	3,93	3,31
1	Пензенская область	11221	3,62	3,27
2	Саратовская область	11086	3,98	3,39
3	Новосибирская область	10985	3,88	3,28
4	Ставропольский край	10947	4,16	3,44
5	Псковская область	10936	3,89	3,34
...				
60	Мурманская область	7218	3,65	3,1
По голштинской породе				
-	Российская Федерация	10082	3,89	3,32
1	Саратовская область	12880	3,91	3,47
2	Ставропольский край	12701	3,82	3,32
3	Оренбургская область	11569	3,87	3,55
4	Воронежская область	11369	3,85	3,50
5	Калининградская область	11317	3,74	3,39
...				
35	Мурманская область	9664	3,71	3,16

Апофеозом всей работы селекционера, как и любого специалиста, является достижение высоких результатов, рекордов.

В США последний известный рекорд – корова Selz-Pralle Aftershock 3918, с фермы Selz-Pralle Dairy (Висконсин). В 2017 году на 5-й лактации за 365 дней она дала 35457 л молока [4, р.1; 5, р.1].

В мире насчитывается более 24 коров с пожизненной продуктивностью более 200 тыс. кг молока [6, р.1]. Самый высокий показатель был отмечен у коровы Nor-Bert Colby Connie (Бремен, штат Индиана, США). В 2023 году в возрасте 14 лет она побила рекорд пожизненного удоя. Ее удой составил 486300 фунта, или 220581 литров молока [7, р.1].

В России также появляются коровы-рекордистки. Так в Тверской области в 2016 году корова

Марта за 305 дней удоя дала 20702 кг молока [8, р.1]. В Рязанской области в 2023 году в хозяйстве «Шацк» корова Аллея в возрасте 5 лет показала рекордный удой 20278 кг молока [9, р.1].

В Мурманской области в ООО «Полярная звезда» по итогам 2022 года 3 коровы достигли уровня 15 тыс. кг молока (табл.3). Среди них на втором месте – корова Аргентина 1244. Это рекордистка Мурманской области 2023 года. За 305 дней лактации ее продуктивность составила 19171 кг молока. Это ее четвертая лактация. Обратите внимание на график результатов контрольной дойки животного (рис.3). Продуктивность Аргентины на третий месяц лактации составляла более 80 л.

Лучшие коровы ООО «Полярная звезда» (голштинская порода) на 2022 год

Кличка, №	Отец	Линия	Наивысшая лактация (305 дней)			
			№	Удой, кг	% жира	% белка
Муза 582	Солярис 61492131	Р.Соверинг 198998	6	15248	3,8	3,28
Аргентина 1244	Улан М 11491930	В.Б.Айдиал 1013415	3	15012	3,8	3,34
Дуга 1376	Лоберг М 472038	Р.Соверинг 198998	3	15061	3,74	3,27
Сибирская 1463	Лоберг М 472038	Р.Соверинг 198998	2	14899	3,78	3,28
Ирландия 1101	Мегре М 51002781	В.Б.Айдиал 1013415	4	14427	3,75	3,33
Улуска 41755	Трибунас 465647	В.Б.Айдиал 1013415	2	14306	3,73	3,26
Мамалыга 1636	Тотти М 50665626	Р.Соверинг 198998	3	14293	3,73	3,29
Альбинка 859	Флегрей 51002788	В.Б.Айдиал 1013415	4	14007	3,8	3,33

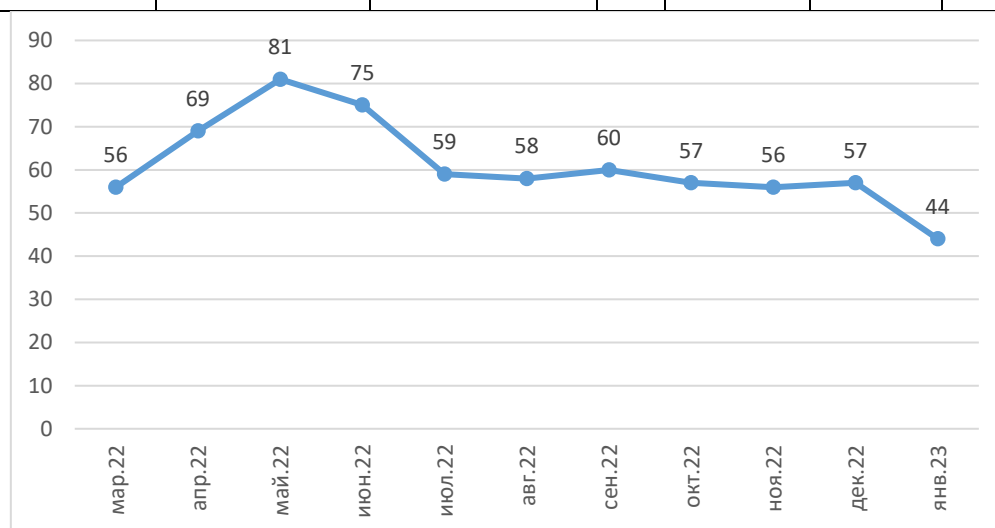


Рисунок 3 – Результаты контрольной дойки коровы Аргентина 1244 в 2022-2023 годах.

Аргентина является дочерью быка Улан (племобъединение Московское). По данным ВНИИП-лем этот бык дает существенную прибавку в удое. Он представитель линии В.Б.Айдиал. Ее мать Амнистия 279 является представителем семейства

Ария 489, ее максимальная продуктивность на 5 лактации составила более 10 тыс.кг молока. Также необходимо отметить, что отцом матери является бык Линкс, с довольно высоким результатом оценки племенной ценности (рис.4).

Аргентина
1244

Улан М 11491930,
линия В.Б.Айдиал 1013415, класс А1
Оценка ПЦ:
ПО Московское: удой - 14193 (+304 кг), %жира - 3,97 (-0,04), %белка - 3,27 (-0,04)
ВНИИплем (2021): удой +557, %жира -0,11, %белка -0,11

Амнистия 279,
семейство Ария 482,
макс.прод. (5 л.) -10293-3,85-3,26

Линкс М 51269814, линия Р.Соверинг 198998, класс А2
Оценка ПЦ ВНИИплем (2021): удой +206, %жира -0,04, %белка +0,01

Аевита 31455

Ломбардо 61740360, линия Р.Соверинг 198998, класс А151

Айва 285

Рисунок 4 – Родословная коровы Аргентина 1244

С учетом того, что нами в 2021 году проводили исследования в данном хозяйстве по изучению влияния семейств и линий на потомство методом BLUP. Ниже представлены данные по продуктивности предков Аргентины, полученные в результате анализа данных по стаду с 1998 по 2020 год (табл.4). В частности, согласно нашей оценке и Улан и Линкс имели отрицательные результаты при оценке племенной ценности. По всей видимости, существенное влияние оказало падение продуктивности в стаде именно в период использования этих быков. В то же время хочется отметить, что с материнской стороны отмечается довольно высокая продолжительность жизни у матери и ее матери с неплохим потенциалом продуктивности. И хотя семейство Ария 489 обеспечило незначительное превосходство по удою (всего +63 кг), общее количество потомства говорит о достаточно высоком продуктивном, и не только, потенциале этой генеалогической группы.

Таблица 4

Продуктивность и племенная оценка (ПЦ) предков Аргентины 1244 в ООО «Полярная звезда»

	Генеалогическая группа	Число потомков	Ср.удой по всем лактациям за 305 дней, кг	Ср.удой по 1 лактации за 305 дней, кг	Ср.удой по 2 лактации за 305 дней, кг	Ср.удой по 3 лактации за 305 дней, кг	ПЦ, кг
Отец	Улан М 11491930	30	9037±185	8843±216	9302±322	-	-227
Линия отца	В.Б.Айдиал 1013415	1669	8981±36	8431±50	9264±71	9339±93	+62
Мать	Амнистия 279	-	7891 (5 лакт)	4469	7068	8892	-
Семейство	Ария 482	75	8988±169	8542±237	8799±337	9784±427	+63
Отец матери	Линкс М 51269814	15	6425±459	4704±118	7411±374	8619±273	-264
Линия отца матери	Р.Соверинг 198998	1278	9098±45	8682±62	9435±88	9429±127	+27
Мать матери	Аевита 31455	-	9060 (5 лакт)	9543	9954	11596	-

В заключение необходимо отметить, что современные методы селекционной работы становятся все более специализированными и точными, однако реализация заложенного в животном потенциала существенно зависит от условий его содержания и организации производства. Поэтому получение высокопродуктивных животных, рекордисток породы возможно только в результате успешного сотрудничества специалистов разного профиля и работников хозяйства.

Благодарность: Выражаем благодарность коллективу ООО «Полярная звезда», главному зоотехнику Сидоровой Л.Н.

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ROOT VEGETABLES AND THEIR ROLE IN HUMAN NUTRITION**Batirov Kh.**

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ОВОЩНЫЕ КОРНЕПЛОДЫ И ИХ РОЛЬ В ПИТАНИИ ЧЕЛОВЕКА**Батиров Х.Ф.**

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Abstract

The article provides information about the role and features of rational nutrition of people, which is associated with uninterrupted provision throughout the year with balanced protein, vitamins, carbohydrates, etc. products not only due to bread and bakery products, but also favorite fruits, vegetables and other crops. The authors make very logical conclusions that biennial vegetable crops play a special role in the nutrition of the population, which, according to the authors, form 2-3 crops per year when irrigated.

Аннотация

В статье приводятся сведения о роли и особенностях рационального питания людей, которые связано с бесперебойным обеспечением в течение года сбалансированными по белку, витаминам, углеводам и т.д. продуктами не только за счет хлеба и хлебобулочных изделий, но и любимых плодовых, овощных и других культур. Авторы делают весьма логичные выводы, что двулетние овощные культуры занимают особую роль в питании населения, которые, как считают авторы, при орошении формируют 2-3 урожая в год.

Keywords: human nutrition, balance of products, calorie content of food, environmental aspects, food security, vegetable biennials, 2-3 crops;

Ключевые слова: питание людей, сбалансированность продуктов, калорийность пищи, экологические аспекты, продовольственная безопасность, овощные двулетники, 2-3 урожая;

Введение. Известно, что обеспечение населения земного шара продуктами питания относится к числу наиболее актуальных проблем, которое имеет глубокие исторические корни и с которой история человечества связана с борьбой за пищу. Продовольствие всегда выступало и выступает

неотъемлемой частью жизненных средств, и нарастание по тем или иным причинам его дефицита справедливо воспринимается как бедствие, требующее адекватных действий.

Следовательно, недостаточность питания у людей представляет экологическую проблему, и она является конечным результатом, тесно взаимосвязанных между собой факторов физического, биологического и культурного окружения человека. Количество различных пищевых продуктов и питательных веществ, доступных людям различных возрастов, будет зависеть условий окружающей среды: климата, почв, транспорта, сохранения выращенного урожая, а также от уровня производства и т.д. [1, с. 7; 2, с.215].

Многочисленные данные свидетельствуют, что продовольственная проблема представляет собой сложное комплексное явление, которое требует более широких подходов. Пища, в своей первооснове принадлежащая среде обитания, используется уже как продукт культуры и в этом смысле, для взрослого человека при среднем режиме работы требуется в пределах 3 тыс. килокалорий за сутки [3, с.146; 4, с.164].

Усреднённый мировой показатель пищевых энергетических потребностей определён экспертами ФАО и ВОЗ в 2385 килокалорий в сутки на человека. Наибольшую биологическую ценность представляют белки, которые необходимы организму, прежде всего, как пластические вещества для образования клеток и тканей. Белковая недостаточность особенно отрицательно сказывается на здоровье детей, вызывая дистрофию и другие трудноизлечимые болезни [11, с.246].

Однообразное питание, исключение из рациона на длительный срок отдельных групп пищевых продуктов нарушают сбалансированность пищевых компонентов, понижают усвояемость и синтез веществ. Пищевой рацион различен для разных климатических зон. Меняется нормирование углеводов, удельный вес которых в питании повышается для жителей южных районов и снижается для северных. Для детей, учитывая физиологические особенности растущего организма, разработаны особые нормы питания. Питание же пожилых людей строится с учётом особенностей организма, в котором происходит снижение интенсивности и замедление обменных процессов систем организма человека [5, с.41; 7, с.150].

В то же время, биологическая специфика человека требует постоянного потребления животного белка и витаминов. Ведь, правильное соотношение основных компонентов пищи и её калорийность настолько важны для здоровья населения, что побудило разработать научно-обоснованные нормы питания для населения стран. Кстати, в мире одно из первых мест занимают японцы, которые из числа имеющихся более 1200 наименований овощных культур выращивают более 400, россияне 200, а население Центральной Азии в пределах 40-45 и т.д. [12, с.350; 8, с.326].

При этом эти страны исходят из того, что белки обеспечивают 15% суточной калорийности

(из них не менее 1/3 животного происхождения), жиры – 30%, а углеводы – 55%. В пищевой рацион включают мясо, рыбу, молочные продукты (основные источники белков и жиров), а также овощи и фрукты (источник углеводов, минеральных веществ, витаминов). В составе пищи необходимы также микроэлементы (фосфор, железо, йод, калий, кальций и др.), осуществляющие важные регуляторные функции. Потребности человека в энергии, которую он получает из пищи, зависят как от индивидуальных особенностей организма (пола, возраста, веса, роста, обменных процессов), так и от характера трудовой деятельности, условий быта, отдыха и окружающей среды (прежде всего от климата).

Необходимая калорийность компенсировалась большим потреблением хлеба – 190 кг, а также картофеля, капусты и других овощей – более 300 кг. В таких рационах не хватало многих необходимых организму компонентов – белков, жиров, витаминов, но зато было очень велико содержание углеводов. Подобный характер питания отрицательно отражался на состоянии здоровья, способствовал появлению многих болезней и в первую очередь, болезней органов пищеварения.

Следовательно, борьба с неправильным питанием далеко не всегда может привести к успеху в условиях, когда часть населения не получает минимально необходимого количества пищи. Важнейшей причиной голода в мире служит недостаток пищевого белка, который в настоящее время составляет 15 млн. т в год.

Причины обострения продовольственной проблемы деградация окружающей среды оказывает более сильное влияние на продовольственную ситуацию в мире, нежели экономические и социальные тенденции. В результате почвенной эрозии, которой подвержено около трети посевных площадей в мире, ежегодно из хозяйственного оборота выпадает от 6 до 7 млн. га земель, а из-за процессов заболачивания и засоления, поразивших от четверти до половины орошаемых земель до 10 млн. га.

Сельскохозяйственная продукция, выращенная на полях с интенсивным использованием азотных удобрений, содержит высокое количество нитратов, которые вызывают у детей и взрослых в различной степени заболеваний. Более того, в пищу вводят различного рода пищевых добавок для улучшения их качеств. Продукты питания могут оказаться загрязненными и радиоактивными изотопами – стронцием-90, цезием-137, йодом-131 и другими.

Широко известны случаи возникновения серьезных эндокринных заболеваний у детей, употреблявших в пищу мясо бройлеров, в корма которых добавляют гормоны. Молоко кормящих женщин в загрязненных районах содержит пестициды и другие ксенобиотики.

Экологические аспекты продовольственной проблемы настоятельно диктуют уделять особого внимания по предотвращению ухудшения окружающей среды с целью преодоления экологических трудностей. Экологические ошибки при решении

проблем сельского хозяйства оборачиваются для населения трагическими последствиями. Ярким примером тому является рациональное питание и принятие здорового образа жизни людей.

Между тем корнеплоды и другие двулетники могут удачно восполнить этот пробел при условии, если будут учтены биологические и технологические особенности этих культур при выращивании для различных целевых назначений и, в первую очередь, для целей сидерации. Здесь они удачно могут сочетаться не только с хлопчатником, но и с другими культурами.

В настоящее время повсеместное возделывание овощных культур и широкое распространение их представителей на орошаемых землях Узбекистана обусловлено довольно высокими пищевыми и вкусовыми достоинствами, а также значением как дешевого и доступного источника витаминов углеводов и других полезных для человека веществ. Между тем по производству и ассортименту овощей Япония занимает ведущее место и если она производит более 250-300 их видов, то Россия занимающая 2-ое место производит около 200 видов, тогда как в Узбекистане производят только около 40 их видов и т.д.

Следует особо подчеркнуть, что пищевая ценность овощных культур определяется прежде всего содержанием как в подземных, так и надземных частях в достаточном количестве углеводов, органических кислот, минеральных солей, витаминов и других химических соединений. Кроме этого в продуктах овощных культур содержатся различные ароматические, красящие вещества, которые придают им особый аромат и внешний вид.

Особенностью являются также и то, что они отличаются высоким содержанием воды, калорийностью, имеются жиры, белки, углеводы и т.д. Поэтому в моркови, свекле столовой преобладает сахароза, а клетчатка, содержащая в них, способствует лучшей переваримости принимаемых человеком в организм пищи. Пектиновые же вещества, содержащиеся в стенках плодов овощей под воздействием ферментов, превращается в пектин, который хорошо растворяется в воде.

В плодах двулетних овощей также содержатся и азотистые вещества, представляющие главным образом белками (у чеснока к примеру они в пределах до 6%), гликозидами, обладающие вкусом горечи и т.д. Кроме этого в составе овощей имеются и жиры (в незначительном количестве, т.е. 0,1-0,4%) органические кислоты, пигменты, каротины, эфирные масла, а так же целый ряд витаминов. И так, овощные двулетние культуры относятся к числу основных и незаменимых пищевых продуктов и потому сыграют важную роль в организации правильного и рационального питания среди населения нашего региона.

Поэтому у нас в зависимости от географических условий регионов, жизненного уровня, привычек живущих в различных областных территориях, а так же привычек населения к употреблению в различной степени тех или иных пищевых продук-

тов (по различным их видам) в средней степени годовая норма и норма овощей по отдельным видам потребления бывают у нас различными. Так, эти нормы согласуют на основании потребительских возможностей населения со стороны Минздрава Республики Узбекистан в прошлом было овощей на душу населения в пределах 80-85 кг, то в годы независимости средняя норма достигло в 90 ые годы 90-95 кг, то в настоящее время планируется на уровне примерно 135-145 кг овощей на душу населения.

Главной их особенностью заключаются в том, что они не требуют дополнительной площади, масированных доз удобрений, воды и т.д. и отличаются простотой технологических приемов, которые могут быть использованы для различных целевых назначений и за короткий промежуток времени способны формировать высокие урожаи биомассы (Турсунходжаев З.С., Болкунов А.С., 1987; Х.Ф. Батиров, 1997, 2022; Ш.А. Халилов, 1988; и другие). Кроме того, промежуточные культуры могут повысить коэффициент землепользования орошаемой пашни с нынешнего 0,65-0,79 до 2,0-2,9 раза, выполняя важную роль в защите почв от эрозии, засоления и заболачивания земель.

Благодаря их посевам улучшаются физические, технологические свойства почвы, биологическая её активность, способствует мобилизации фосфатов и с их помощью можно бороться против сорняков, болезней и вредителей с.-х. культур, а также защищают почву от эрозии и наконец, промежуточные культуры являются важным резервом увеличения производства высокобелковых кормов за счет зерновых, бобовых, капустных и др. представителей (Кант г., 1981; Довбан К.И., 1990).

Таким образом, выращивание после уборки хлопчатника осенью и зерновых хлебов промежуточных культур дает возможность без значительных затрат, не сокращая посевных площадей в севообороте, существенно увеличить производство с.-х. продукции. Тем более в этот период имеется наличие тепла, влаги, света и продолжительности благоприятных дней в течение 130-150 дней летом и 150-160 дней в зимний период (Алиханов, М.А., 1981; А.Халиков, 1988).

Материалы и методика. В связи с этим, мы в течение 2017-2023 гг. проводили полевые исследования на орошаемых землях Самаркандской области в вариантах использовали из числа промежуточных культур посева редьки масличной, тифона, ячменя, гороха и их смесей, а в качестве контроля брали, зябь и весновспашку. Семена промежуточных культур высевались на тщательно подготовленном поле в начале октября из расчета тифона 5 кг/га, редьку масличную 20 кг/га, гороха 90 кг/га, ячменя 120 кг/га, а в смесях использовали половинную их норму посева семян.

Закладка, проведение опытов, учёты, наблюдения и анализы по изучаемым культурам проводили согласно методике Б.А. Доспехова (1985) и другим методикам, принятым на орошаемых землях Узбе-

кистана. В опытах применяли агротехнику, рекомендованную для орошаемых условий Самаркандской области (Батиров Х.Ф., 1997, 2022).

Результаты и обсуждение. Исследованиями, проведенными нами длительный период (1997-2017 гг.) установлено, что из числа не бобовых редька масличная, тифон, капуста кормовая, брюква, сурепица озимая и даже из зерновых колосовых ячмень, овес и другие в отличном состоянии (при сохранности 95-98,5% к исходной густоте стояния) перезимовывают и с ранней весны быстрее и дружнее отрастают и за короткий промежуток времени уже в конце марта и начале апреля смогут формировать довольно высокие урожаи (450-510 ц/га) биомассы, которые могут использоваться как сидераты, а затем на корм животным или доращиваться для получения высококачественных семян.

Не бобовые сидераты активно способствуют накоплению органики в почве. Возврат же в какой-то степени на поле части зеленой массы в виде органического удобрения-навоза-это лишь частичная компенсация количества гумуса, разлагающегося в результате обработки почвы, внесения удобрений и т.д. Необходимо подчеркнуть тот факт, что масса корневых остатков пожнивных посевов не бобовых промежуточных культур в наших условиях (при орошении) в зависимости от сроков посева и норм высевки семян может достигать в пределах 35-50 ц/га при ранних сроках, 17-30 ц/га и 5-15 ц/га при поздних сроках их вегетации.

Заметим, что в начале апреля масса одного корня в среднем была у свеклы сахарной 70-75 грамма, столовой свеклы 62-65 грамма, листовой свеклы чуть меньше, редьки масличной, капусты кормовой и тифона соответственно 50-55 грамма, но листьев в месте семенниками у всех представителей было намного больше. К примеру, масса листьев была в пределах 85-131, грамма, а в мае, а тем более в июне была в нарастающем темпе, т.е. в пределах 215-285, а у капустных 330-35 грамма.

И наконец, мы в начале утверждали о том, что двулетники дают семена, урожай которых в 2,0-2,5 раза больше с наилучшими качествами, чем скажем, по сравнению с традиционным (высодочным) способом, который требует два года вегетации, больших затрат труда и средств. При посеве же их семян осенью и путем зимовки прямо на открытом поле, что вполне возможно в наших условиях, и через полгода к лету дает 2,5-3,5 т/га семян с отличными их свойствами.

Кроме того, следует также отметить, что в наших опытах к примеру, капуста кормовая даже при поздних сроках (15 октября) посева к ранней весне формирует 450-475 ц/га фитомассы и 35-50 ц/га корневых остатков, при использовании которых обеспечивается значительное количество накопления гумуса, что полностью компенсирует его потери в процессе возделывания технических и других культур.

Опыты проводились в течение 2017-2023 годов в условиях орошаемых земель Самаркандской области в 4-х кратной повторности с размером делянки 50 м² каждой. Закладка, проведение биометрических учётов, анализов и наблюдений проводились согласно методике полевого опыта по Б.А. Доспехову (М., 1985), данные по урожаю, полученные в опытах подвергались математической обработке дисперсионным методом.

Почвы опытного участка были типичными сероземами давнего орошения с механическим составом среднесуглинистый, а залегание грунтовых вод было в пределах 5-7 метров. В опытах агротехнология была рекомендованной для данной зоны, погодные условия в эти годы были сравнительно благоприятными для формирования высокого урожая биомассы. Между тем довольно интересные данные получены в опытах и по наличию органики в почвах (табл.1).

Таблица 1

Наличие органической массы в пахотном (0-40 см) горизонте почв (Самаркандская область, среднее за 2017-2023 гг.)

Варианты	Рельеф, °С	По горизонтам	Масса растений, ц/га	
			всего	в. т. ч. корень
Зябь (контроль)	0-1,0	выше	-	-
	1,0-2,0	среднее	-	-
	2,0 >	ниже	-	-
Редька масличная	0-1,0	выше	29,1	9,5
	1,0-2,0	среднее	27,0	8,1
	2,0 >	ниже	25,4	7,0
Рожь	0-1,0	выше	27,0	8,2
	1,0-2,0	среднее	25,2	7,7
	2,0 >	ниже	23,0	6,5
Редька масличная +рожь	0-1,0	выше	41,3	13,6
	1,0-2,0	среднее	38,5	11,7
	2,0 >	ниже	35,0	9,9

Данные настоящей таблицы показывают, что при рельефе местности 0-1,0 накопление органической массы у редьки масличной было например 29,1 ц/га, при более 2,0 > же 25,4 ц/га, что у ржи

составило соответственно 27,0 и 23,0 ц/га и в третьем варианте это было в пределах 41,3 ц/га, а при рельефе местности более 2,0 > 35,0 ц/га массы. и т.д. Кроме того провели исследования и относительно влияния сидератов на уровень мерзлоты и

толщины снега в зимний период вегетации растений, что приводится в табл.2.

Таблица 2

Влияние сидератов на замерзание поверхности почвы и толщину снега в опытах (Самаркандская область, среднее за 2017-2023 гг.)

Варианты	Слой по месяцам, см					
	Замерзание почвы			Толщина снега		
	ХП	І	ІІ	ХП	І	ІІ
Зябь (контроль)	5	7	4	0	3	7
Редька масличная	2	3	2	2	5	8
Рожь	2	4	1	3	6	8
Редька масличная +рожь	1	2	2	4	7	10

Как видно из данных таблицы, что в опытах замерзание верхнего слоя почвы и толщина выпавшего снега зимой были довольно незначительными на контроле, нежели других вариантов. Так, например, высокие показатели получены по другим двум

вариантам и надо сказать, что это способствовало вымыванию в меньшей степени фракции и почвенных частиц с пахотного горизонта (табл.3).

Таблица 3

Влияние сидератов на состояние почвенных частиц в опытах

(Самаркандская область, среднее за 2017-2023 гг.)

Варианты	Вымывание частиц по степени эрозии и культур			
	среднее		сильное	
	т/га	%	т/га	%
Зябь (контроль)	6,4	100	9,1	100
Редька масличная	5,1	79,7	7,9	86,8
Рожь	4,8	75,0	7,2	79,1
Редька масличная +рожь	4,0	62,5	5,8	63,7

Из табличных данных видно, что если на контрольном варианте доля намытых почвенных частиц было 6,4-9,1 т/га, то на третьем варианте (совместные посевы двух культур) было на 2,4-3,2 т/га меньше по сравнению с первым вариантом. Надо сказать, что тем самым мы смогли охарактеризовать преимущество сидератов, которые являются мощным средством предотвращения эрозионных процессов на орошаемых землях нашего региона.

Во всех без исключения случаях урожайность зеленой массы сахарной свеклы, тифона, редьки масличной и брюквы по сравнению с другими представителями двулетников была сравнительно высокой. Так, к примеру, если сахарная свекла имела урожай зеленой массы 504,5 ц/га, кормовая и листовая соответственно 412,0 и 437,0 ц/га, то столовая свекла имела 327,0 ц/га, а капустные культуры имели в среднем 450-475 ц/га урожая зеленой массы. Надо полагать, что выращивание какой-либо одной культуры в течение нескольких лет на одном и том же поле приведет к сильному засорению полей, чередование даже озимой пшеницы с ячменем способствует снижению степени засоренности обеих культур.

Заключение. Таким образом, на основе вышеизложенного следует подчеркнуть, что наряду с бобовыми и не бобовые сидераты имеют важное значение в восполнении потери количества гумуса и в пополнении его запасов между двумя урожаями полевых культур в хлопково-зерновом комплексе орошаемых полей. Промежуточные культуры становятся экологически необходимостью, при посеве

которых будут решаться нижеследующие основные задачи:

-активизируется поступление в почву свежего органического вещества в виде кормовых и пожнивных остатков, наличие постоянного растительного покрова, предупреждающего вымывание элементов пищи;

-улучшаются водно-физические свойства почв, микроклимат, является эффективным средством противозеронозных средств, подавляют сорняки, очищая почв от их семян, вредителей, болезней, сглаживают сезонность, увеличивает продолжительность с.-х. растений;

-способствуют более умелому и рациональному использованию рабочей силы, техники, водных ресурсов и других средств, что обуславливает повышение производительности труда в сельском хозяйстве.

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ECONOMIC SCIENCES

THE IMPORTANCE OF SMALL ENTREPRENEURSHIP AND MUNICIPAL GOVERNANCE IN TOURISM

(The case of the Nakhchivan Autonomous Republic of Azerbaijan)

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Abstract

In the modern era, the rapid development of tourism has become one of the leading factors in shaping the global economy, social life, and cultural values. Owing to the widespread application of modern tools and technologies, tourism functions not merely as a form of recreation and entertainment but also as a complex field of activity with multifaceted social, economic, and environmental impacts.

Since tourism is closely linked to the diverse and ever-growing social, cultural, spiritual, and economic needs of human beings, both natural and anthropogenic resources are widely utilized to meet these demands. In today's world, tourism and recreation activities are not only considered sources of economic income but also viewed as key components of social stability, cultural integration, and regional development. This sector plays a crucial role at almost all administrative and hierarchical levels, within the socio-economic structure of regions and in systems of local self-governance.

As a result of tourism development, infrastructure in regions expands, transportation and service sectors modernize, investment attractiveness increases, and social welfare indicators improve. This article examines the role of small entrepreneurship and local self-government bodies in the utilization of tourism and recreational resources in the Nakhchivan Autonomous Republic of the Republic of Azerbaijan.

Keywords: tourism; small entrepreneurship; municipality; Nakhchivan Autonomous Republic

Introduction

Under current conditions, tourism has become one of the main areas of socio-economic development of regions. It contributes to the creation of new jobs, stimulates infrastructure development, supports small and medium-sized enterprises, and shapes the positive image of the region. In an environment of increasing competition among tourism destinations, the activities of local self-government bodies are of great importance, as they possess extensive opportunities to create favorable conditions for tourism development.

Tourism and recreational activities also play an essential role in protecting human health, fostering physical and spiritual development, and enhancing educational and cultural levels. In the modern context, these activities have become among the main indicators of improving the quality of human life and social welfare of society. Through tourism, individuals not only rest but also learn, observe, gain new experiences, and develop intercultural communication skills.

Tourism is no longer merely a form of travel but a spiritual process that shapes a person's worldview, way of thinking, and system of values. In this respect, it serves as an integral component of an active and meaningful lifestyle in the modern world — a tool for socialization and self-realization (Bilalov, 2006).

The scientific classification of tourism and recreation resources facilitates their study, evaluation, and management. Based on this classification, the tourism potential of a specific area can be determined, and strategies for tourism development are designed accordingly.

The quality indicators of resources are measured by the following factors:

- accessibility level;
- ecological condition and degree of protection;
- potential for integration into infrastructure;
- socio-economic efficiency, and others.

Tourism and recreation resources form not only the basis for creating tourism products but also the foundation for the socio-economic development of regions. Their comprehensive study and accurate classification enable the implementation of tourism policy on a scientific basis.

The economic assessment of tourism and recreation reserves is of great importance in terms of their involvement in economic circulation, management, and protection. Natural and cultural resources used in tourism activities possess not only ecological and social value but also serve as productive factors generating economic benefits.

Entrepreneurial activity in the tourism industry represents a multifaceted economic process encompassing the development of commercially competitive services, the allocation of capital across different sectors, the efficient use of natural resources, disease prevention, and the improvement of service quality provided to tourists (Yakovenco, 2016).

In modern times, enterprises in the tourism industry no longer limit themselves to meeting only the traditional needs of tourists — such as accommodation, food, and treatment — but also provide additional services. These include organizing excursions, selling souvenirs and tickets, as well as hosting entertainment and sports events. Such diversification not only increases profitability but also enhances the overall quality of recreation and treatment. Therefore, the infrastructure

factor is considered one of the most profitable and strategic components in the design of hotels and sanatoriums.

Tourism companies play an important role in the country's economic development, in increasing employment, and in improving social welfare. Entrepreneurial activity in tourism not only involves the sale of services but also pursues broader social objectives — such as health protection, job creation, and professional development.

Modern consumers prefer high-quality services and are willing to pay higher prices for them. This, in turn, intensifies competition in the tourism market and leads to higher service standards.

Discussion

The tourism industry consists of numerous small business entities. Although these enterprises may not have strong influence at the decision-making level, they often unite into associations to defend their interests. These associations play a crucial role in unifying service quality standards, standardizing ticket forms, and coordinating operational activities.

Local self-government bodies, taking into account regional specificities, are capable of effectively coordinating activities related to the improvement of territories, ensuring tourist safety, creating a comfortable environment, and promoting local cultural and natural resources (6). Their participation in the management of the tourism sector is essential for ensuring the sustainable development of tourism and establishing a harmonious balance between economic, ecological, and social interests.

Local self-government bodies play a key role in ensuring the comprehensive development of territories. They serve as a connecting bridge between state structures, businesses, and local populations (Salimzade, 2010). Their activities are aimed at creating favorable conditions for life, investment, and particularly the development of tourism.

According to the European Charter of Local Self-Government, local self-government bodies have the right to independently address local issues in accordance with the interests of the population. This enables them to design their own socio-economic development programs that include strategic directions for tourism.

Municipalities can respond flexibly to changes in market conditions and tourist demands, making them key actors in territorial marketing. In several countries (e.g., France, Germany, Switzerland), programs for regional branding and the protection of cultural heritage are implemented precisely at the municipal level.

In the context of tourism development, the main functions of local self-government bodies include the following:

- planning and implementation of improvement programs;
- organization of public safety and environmental services;
- support for local entrepreneurs operating in the tourism sector;
- participation in the formation of regional tourism strategies;

- promotion and protection of cultural and natural monuments.

Local self-government bodies also ensure interaction among various stakeholders — the population, businesses, tourists, and state institutions. Thus, they act as coordinators of tourism development at the local level.

Ensuring the safety of tourists is also a priority duty of local authorities (9). Their responsibilities include maintaining sanitary conditions, managing waste, and monitoring the quality of water and air. Municipalities also establish emergency response services and develop plans for the prevention of emergencies.

Successful tourism development is impossible without the support and participation of the local community. Municipalities should consider the interests of residents and involve them in the planning and implementation of tourism projects. In the digital era, tourism promotion is not possible without online tools. Municipalities create official tourism websites, mobile applications, and social media pages that provide up-to-date information about routes, events, and monuments.

Tourism can bring benefits not only to the economy but also to the social sphere. Local self-government bodies use tourism revenues for the improvement of territories, the construction of sports and cultural facilities, and the support of education and healthcare. Thus, the development of tourism at the municipal level becomes a means of improving the quality of life and increasing social activity among citizens.

However, the increase in tourist flows can sometimes create social tension in society. The task of local self-government bodies is to establish a balance between the interests of tourists and residents. This is achieved through measures such as limiting the number of tourists in certain areas, regulating public catering and transportation services, and organizing public hearings on tourism-related issues.

In the Republic of Azerbaijan, particularly in the Nakhchivan Autonomous Republic, tourism plays a special role in economic diversification, employment, and the international recognition of the region. The rich natural, historical, cultural, and therapeutic resources of Nakhchivan create favorable conditions for the development of tourism. Efficient utilization of this potential primarily depends on the activity of local administrative bodies, the initiative of small entrepreneurs, and the strengthening of state-municipal cooperation.

The Nakhchivan Autonomous Republic is one of the unique recreational regions due to its natural-geographical location, climatic diversity, and rich mineral waters. The Duzdag treatment complex, Badamlı mineral springs, Batabat plateau, Ashabi-Kahf sanctuary, Noah's Mausoleum, Ordubad city, and other resources constitute the foundation of the region's tourism and recreation potential.

In recent years, the State Program for the Development of Tourism in the Nakhchivan Autonomous Republic for 2023–2027 (1) has strengthened the institutional framework of the sector and accelerated the implementation of infrastructure projects (roads, hotels, recreation centers). The expansion of tourism activities

in Nakhchivan stimulates entrepreneurial initiatives, revitalizes the local economy, and promotes the region's environmentally sustainable development.

An optimal model for tourism development in Nakhchivan is being formed based on cooperation among the state, municipalities, and entrepreneurs. The state carries out structural reforms and economic incentives, municipalities ensure the efficient use of local resources, and entrepreneurs provide innovative services. The effectiveness of this tripartite model leads to increased investment attractiveness and cluster-based development of the tourism industry. At the same time, such cooperation is essential for the development of new directions — including ecotourism, agritourism, and health tourism.

Thus, the Nakhchivan Autonomous Republic, with its rich tourism and recreational resources, creates wide opportunities for the socio-economic advancement of the region. To fully and efficiently utilize this potential, it is important to promote small entrepreneurship, improve municipal management mechanisms, and strengthen coordination with state institutions.

Conclusion

In the modern era, the tourism and recreation sector functions as an important component of socio-economic development. The formation and advancement of tourism-recreation systems have become a vital field of activity that ensures the integration of socio-economic, cultural, and ecological processes.

Research demonstrates that tourism is not merely a source of economic income but also a multifaceted social institution that promotes regional development, public welfare, and ecological balance. The sustainable development of tourism-recreation systems today requires the synchronized functioning of state policy, scientifically based planning, and local governance mechanisms.

The role of small entrepreneurship in this system is particularly significant. Through the initiatives of local entrepreneurs, the variety of tourism services expands, employment opportunities increase, and the social welfare level of the population improves. The active participation of small businesses in the development of tourism infrastructure — including family-type hotels, rural tourism facilities, public catering, and transport services — creates a localized yet sustainable model of regional economic growth. The interaction between municipalities and entrepreneurs, therefore, provides a foundation for tourism development based on the principle of social responsibility.

The study confirms that the role of municipalities in tourism policy should not be limited to administrative control and territorial planning. They must also act as coordinators of tourism initiatives, guarantors of fair resource distribution, and supporters of small entrepreneurship. Within this model, the division of powers between state authorities and municipalities must be clearly defined, and the interests of local communities must be reflected in economic decisions. This approach

ensures transparency in the tourism sector, efficient use of resources, and social justice.

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A CLUSTER ANALYSIS OF ARMENIA'S STRATEGIC ROLE IN THE GLOBAL BLOCKCHAIN LANDSCAPE

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Abstract

The aim of the study is to quantitatively assess Armenia's strategic role in the global blockchain ecosystem, revealing the country's position relative to global competitors. The study was conducted on a selection of 50 countries, using a number of other elements: cryptocurrency adoption, innovation potential, and digital infrastructure. For practical analysis, the K-means clustering method was used, which allows classifying countries into homogeneous groups, as well as Principal Component Analysis (PCA).

As a result of the cluster analysis, three main clusters were identified: "Global Leaders", "Emerging Integrators" and "New Entrants". Armenia falls into the "Emerging Integrators" cluster, which is characterized by an above-average innovation potential (≈ 0.53) and a strong digital infrastructure (≈ 0.8), but a relatively low crypto adoption rate (≈ 0.019).

In addition to cluster analysis, an optimization model was also used, which showed that Armenia's transition to the "Global Leaders" cluster will require capital investments, a sharp improvement in the legislative framework, and human resource development.

This research fills a scientific gap by providing a quantitative assessment of Armenia's position on the global blockchain map and forming a practical basis for developing targeted state policies, optimal resource allocation, and technological integration strategies.

Keywords: Blockchain, cluster analysis, innovation index, digital economy, armenia, strategic positioning.

Introduction: Blockchain technology, based on the immutability principle of Distributed Ledger Technology (DLT), has expanded beyond cryptocurrencies in the last decade to become a key driver of the global digital economy[10]. Global market analysis shows that by 2030, the volume of investments in blockchain technologies will increase dramatically, forming the infrastructure of a new digital economy. In this context, the Republic of Armenia, which has a strong engineering tradition and a developing technological ecosystem, aspires to become a regional digital center. According to official reports, Armenia's IT sector is showing a steady growth of more than 20% annually, and the Innovation Index (0.534) and Digital Infrastructure Index (0.8) correspond to an above-average level compared to a sample of 50 countries. These indicators indicate that Armenia has the technological readiness for the adoption and spread of blockchain.

However, there is a significant disparity between Armenia's high-tech potential and the market adoption of blockchain: the Crypto Adoption Score is only 0.019, which proves that technological capabilities are not yet fully reflected in the level of market integration.

A study of global blockchain strategies shows that the key success factors for large and small economies are strategic government support, an open regulatory

environment, and policies aimed at human capital development. However, for small and developing economies like Armenia, what is needed is not a direct transfer of the experience of world leaders, but a comprehensive quantitative modeling that will allow understanding the interaction between the country's innovation potential and investment constraints[4]. In this regard, this study fills a scientific gap by providing a quantitative assessment of Armenia's position on the global blockchain map based on multivariate statistical analysis and optimization modeling.

The main objectives of the research are:

- to quantitatively assess Armenia's integration into the global blockchain ecosystem,
- to identify the factors that shape the country's position in different clusters,
- to develop the structure of strategic investments that will have the greatest impact on Armenia's level of blockchain integration.

Therefore, three main research questions are formulated:

1. What is Armenia's level of integration into the global blockchain ecosystem compared to 50 countries?
2. By what factors do different clusters (e.g. "Strategic Transformation Nodes" and "Adjustable Potential

Levers”) differ according to the main components identified by PCA?

3. What are the optimal investment directions that will have the greatest impact on Armenia’s blockchain integration and strategic positioning?

Literature review: The literature has extensively explored the theoretical foundations of blockchain and its transformative potential[5][9]. Recent research has focused on quantifying the economic impact of blockchain. Tapscott and Tapscott[10] highlight the importance of creating an “Internet of Value” that enables decentralized and intermediary-free transactions. Scholarly sources document that blockchain adoption is positively correlated with a country’s GDP growth and digitalization indices[3]. However, this impact varies greatly depending on a country’s digital infrastructure, level of human capital, and regulatory environment[1]. A significant number of studies analyze the role of blockchain in increasing financial inclusion[1] and ensuring transparency in supply chains[7]. The general consensus is that active government support and “open” regulation are vital for the blockchain ecosystem to flourish. Attempts to map the global blockchain landscape have been made in both academic and corporate circles. Corporate reports often use multi-attribute indices to rank countries by blockchain readiness criteria (e.g., regulatory framework, talent, funding). Academic studies that use cluster analysis typically classify countries into four to five main clusters: “Leaders”, “Followers”, “Potential”, and “Needs Development”[8]. These studies often use Principal Component Analysis (PCA) or Factor Analysis to reduce multiple indicators to one or two main dimensions (e.g., “Innovative Capacity” and “Regulatory Support”). This methodology allows for a quantitative determination of a country’s position, free from subjective assessments.

Particular attention has been paid to the role of small countries, which often have flexible regulatory bodies and small communities of highly qualified IT professionals. For example, Malta, Switzerland (Crypto Valley), and Singapore are seen as small economies that have become global blockchain hubs thanks to their regulatory approaches[2][6]. The successes of these countries demonstrate that economic size is not necessarily a barrier if there is strategic government support and an innovation culture. However, regional (Caucasus) comparative analyses using quantitative cluster models remain limited.

Despite the general mapping of the global blockchain landscape, a specific scientific gap is observed in the quantitative assessment of Armenia’s strategic position. The existing literature mainly focuses on developed countries or on individual technical aspects of blockchain. There is a lack of a model that would apply cluster analysis to rank Armenia among global competitors based on multiple socio-economic and technological indicators. Moreover, there are no publications that would apply optimization modeling to provide clear indications on how Armenia can maximize (max) its integration index given the available resources and constraints (e.g. budget, infrastructure). This study aims to fill this gap by providing a quantitative, methodologically rigorous

analysis that will serve as a basis for informed policy development.

Methodology: The methodology of the present study is based on quantitative and comparative analytical approaches, the purpose of which is to reveal the position and strategic role of Armenia in the global blockchain ecosystem. The study was conducted in three stages: data collection, cluster analysis, and optimization assessment.

In the first stage, open data was collected from various international sources, including the annual reports of the World Bank, OECD, Statista, and Chainalysis. The data included the level of blockchain technology adoption, digital asset turnover, investment climate indicators, as well as assessments of the legal and institutional environment for different countries.

In the second stage, cluster analysis was performed using the K-Means and Hierarchical Clustering methods, aiming to classify countries by the level of blockchain development and adoption. The data was normalized using the Z-score method to reduce the impact of different doses. The optimal number of clusters was determined using the Elbow Method and Silhouette Score criteria.

At the final stage, an optimization analysis was conducted to assess the factors whose improvement could contribute to Armenia’s transition to a more advanced cluster, the so-called “Global Leaders” group. For this purpose, a baseline regression and multi-criteria optimization model was built that assesses the impact of investments, legislative reforms, and technological innovations on the competitiveness of Armenia’s blockchain sector.

The research methodology is aimed at ensuring the comparability and objectivity of the results obtained, allowing for the formation of a scientific justification for Armenia’s strategic position and development potential in the global blockchain environment.

Analysis: The aim of the study is to quantitatively assess Armenia’s position in the global blockchain ecosystem based on key indicators of digital readiness, innovation potential, and cryptocurrency adoption. For this purpose, a comparative analysis framework was selected, covering 50 countries representing different levels of economic and technological development.

The study is based on four key metrics, which are considered key factors in blockchain integration and technological readiness[7][4].

1. Crypto Adoption Score - reflects the degree of mass adoption of cryptocurrencies by the population of a given country. It serves as the best proxy for the financial activity of blockchain.

2. Innovation Index - shows the development of the country’s overall innovation ecosystem, which is directly related to the ability to create and implement blockchain and other innovative technologies.

3. Digital Infrastructure Index - reflects the physical and technical foundations (e.g. network quality, data centers) necessary for the operation of any digital technology, including blockchain.

4. Internet Penetration (%) - shows the percentage of the population that has internet access, which is a

fundamental prerequisite for mass adoption of blockchain.

The indicators calculated for Armenia are:

- Crypto Adoption Score -0.019 (Low score, indicating limited mass adoption).
- Innovation Index - 0.534 (Above average, consistent with the country's IT role).
- Digital Infrastructure Index - 0.80 (High, indicating a strong technical foundation).

These data indicate a gap between a high-tech foundation and market adoption, which was further confirmed by the results of the caste analysis.

To ensure the accuracy of the multivariate analysis, all variables were standardized before conducting the K-means clustering and PCA analyses. The Z-Score method was used, which brings each indicator to the same scale, having a zero mean and one standard deviation. This process prevents the situation where variables with a large value range dominate the analysis.

To divide the countries in the data set into homogeneous groups (clusters), the K-means clustering algorithm was used, which aims to minimize the sum of squared errors (SSE) within the groups. The optimal number of clusters was determined using the Elbow method.

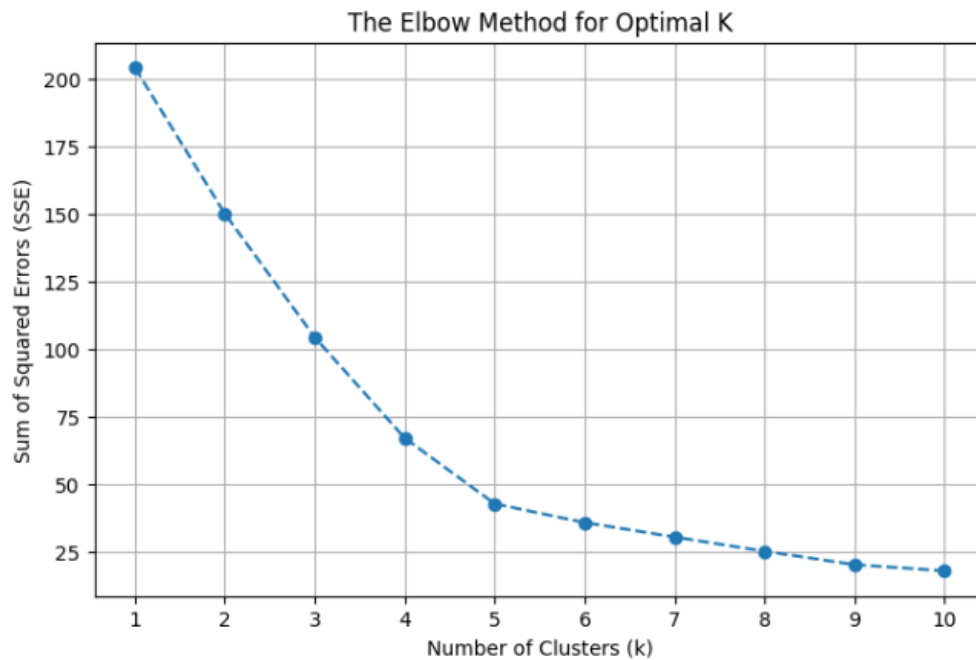


Figure 1 : Elbow metod klasteras

Examination of the graph shows that the Elbow forms at K=3, indicating that the separation of three clusters provides an optimal balance between intra-cluster homogeneity and the number of clusters. Therefore, the value of K=3 was chosen for further analysis.

PCA was applied for two main purposes:

a) To reduce the multidimensionality of the four indicators

b) To show how the baseline indicators cluster into new Principal Components (PCs).

The application of the K-means algorithm revealed three distinct groups of 50 countries based on blockchain adoption, innovation, digital infrastructure, and internet access.

	Crypto_Adoption_Score	Innovation_Index \
Global Leaders (K0)	0.217	0.479
Emerging Integrators (K1)	0.043	0.711
New Entrants (K2)	0.128	0.845
	Digital_Infrastructure_Index	Internet %
Global Leaders (K0)	0.770	0.769
Emerging Integrators (K1)	1.000	100.000
New Entrants (K2)	0.914	1.071
Armenia's Classification: Global Leaders (K0)		

Figure 2: Mean indicators for each cluster

The figure allows us to characterize each cluster.

The "Global Leaders" cluster shows the highest average values for all four indicators, especially in

terms of Crypto_Adoption_Score and Innovation_Index. They represent the most advanced countries in the implementation of blockchain and digital technologies.

The "Emerging Integrators" cluster occupies an average position, having a fairly high Internet access

indicator, but they are inferior to the leaders in terms of Crypto_Adoption_Score and Innovation_Index.

The “New Entrants” cluster is characterized by the lowest values for all four indicators, which indicates that they are at the very initial stage of development.

Table 1:

Classification of Countries by Cluster

Global Leaders	Emerging Integrators	New Entrants
Armenia	Saudi Arabia	Estonia
Azerbaijan	UAE	Latvia
Georgia		Lithuania
Russia		Turkey
Ukraine		Israel
Kazakhstan		Qatar
Uzbekistan		Germany
Kyrgyzstan		France
Tajikistan		Italy
Moldova		Spain
Belarus		Poland
Iran		Netherlands
India		Sweden
Indonesia		Norway
Philippines		Finland
Vietnam		Switzerland
Brazil		China
Mexico		Japan
Argentina		South Korea
Nigeria		Singapore
South Africa		Malaysia
Egypt		Thailand
Kenya		USA
		Canada
		Chile

1. *Global Leaders*. This cluster is characterized by the highest average values in all four indicators, especially in the Crypto Adoption Score and Innovation Index. The group includes Emerging Markets (e.g. India, Nigeria, Brazil), where high crypto investment is driven not by institutional factors but by financial instability and the need for money transfers (P2P motives).

2. *Emerging Integrators*. This cluster (Saudi Arabia, UAE) has excellent digital infrastructure indicators (Digital Infrastructure Index), but a moderate average level of crypto investment. It represents countries with high resources and government support, which are ready for integration, but currently exhibit a cautious, centralized management model.

3. *New Entrants*. The cluster consists of highly developed countries in North America and Western Europe. It has the lowest average Crypto Adoption Score

and a medium Innovation Index (compared to K0), indicating the dominance of regulatory frameworks and institutional caution before mass adoption. This group is in the initial, foundational stage of technological integration.

Principal Component Analysis (PCA) was used to reduce the dimensionality of the original four indicators and identify the independent factors underlying them.

Explained VarianceThe first Principal Component (PC1) explains 40.81% of the total variance, and the second Principal Component (PC2) explains an additional 28.80%. Thus, the first two components together explain more than 69.61% of the total variance of the data set, which allows further analysis to focus only on PC1 and PC2 without significant loss of information.

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--- 3. Principal Component Analysis (PCA) ---
Explained Variance Ratio:
PC1: 0.4065 (Cumulative: 0.4065)
PC2: 0.2866 (Cumulative: 0.6930)
PC3: 0.2256 (Cumulative: 0.9187)
PC4: 0.0813 (Cumulative: 1.0000)

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Figure 3: Principal component analysis

The study of PC Loadings allows us to make sense of and characterize the essence of the newly obtained components.

“Basic Digital Infrastructure and Innovation Readiness”. Axis PC1 exhibits the highest negative loadings on the “Digital Infrastructure Index” (-0.7107) and “Innovation Index” (-0.4825) indicators. Although the loadings are negative, their magnitude indicates a strong relationship. This component reflects the level of Basic Digital Capabilities and Innovation Maturity of a country. That is, countries with a high Digital Infrastructure Index and Innovation Index will have a low (negative) score on PC1, and vice versa.

“Crypto Investment Intensity”. Axis PC2 has the highest positive loadings on the “Crypto Adoption Score” (0.6952) and “Innovation Index” (0.6696). PC2 reflects the intensity of actual adoption of blockchain and digital assets, especially in countries where innovation is directly related to the decentralization of financial services. This axis divides countries based on the dynamism of their crypto market. This phase of the analysis confirms that the digital readiness of countries can be effectively measured by two main independent dimensions: one related to the basic infrastructure and innovation capacity (PC1), and the other to the intensity of technological (crypto) investment itself (PC2). Thus, Armenia’s current position can be characterized as an innovation-potential but market-cautious economy that has not yet realized its full potential in the field of blockchain integration.

Optimization model construction - based on the results of cluster analysis, an optimization model was developed, the purpose of which is to maximize the strategic influence in the blockchain sector of Armenia, in conditions of limited resources, that is, it is necessary to find out how and where (in which clusters) the maximum strategic influence can be achieved in the global blockchain through joint investments and political steps, taking into account resource constraints (budgetary, energy, human capital, legislative risk, etc.).

In the model, investment directions are divided into five main sub-sectors: Mining, Node Hosting, Startups, R&D and Exchanges.

The main parameters and constraints of the model are:

- Total investment ≤ 10 million USD[11][12][13],
- Total energy consumption ≤ 4 million USD[14][15][16],
- Jobs created ≥ 80 [17][18],

- Regulatory risk ≤ 0.4 (weighted average)[19][20],
- Talent readiness ≥ 0.6 [21],
- Minimum R&D funding ≥ 1 million USD.

The formulation of the objective function is to maximize Armenia’s strategic impact, taking into account the equivalent efficiency of one million USD investment in each sector.

Optimization calculations have shown that the maximum result is achieved by focusing about 80% of investments on startup development and with minimal mandatory allocations to the R&D sector.

As a result, the value of the calculated objective function was 68.5 points, which represents the maximum level of strategic impact of Armenia’s blockchain investment portfolio.

The searchable results in the model are: the amount of annual investments directed by Armenia to the i -th cluster, $i=1,2,\dots,k$ (k is the number of clusters), the total amount allocated (million USD).

The optimality criterion of the problem is to maximize Armenia’s strategic influence and we will calculate it using the following formula:

$$F_{max} = \sum_{i=1}^k c_i x_i$$

Where c_j is the strategic impact for every \$1 million invested in cluster I . The mathematical model of the problem is:

1. Budget constraint: $\sum_{i=1}^k x_i \leq B$: total investments cannot exceed the budget, meaning that the Republic of Armenia has limited financial resources for investments.

2. Human resource costs (hours / talent availability): $\sum_{i=1}^k j_i x_i \geq J_{min}$: the minimum number of jobs that must be created to ensure employment.

3. Energy constraint: $\sum_{i=1}^k e_i x_i \leq E_{max}$: The total energy consumption cannot exceed the constraint, i.e. the energy capabilities of the IT infrastructure are limited.

4. Legislative risk: $\sum_{i=1}^k r_i x_i \leq R_{max} \cdot \sum_{i=1}^k x_i$, a small market investment confidence indicator.

5. Weighted average talent: $\sum_{i=1}^k t_i x_i \geq T_{min} \cdot \sum_{i=1}^k x_i$, will ensure the educational and technological readiness of the Republic of Armenia.

6. The condition for non-negative filling of variables is: $x_i \geq 0$, since it is a monetary quantity.

The initial data of the problem is presented in the table (Table 3).

Table 2:

Numerical model of the problem

Cluster	Strategic impact per \$1M invested (economic/strategic units per 1 million USD) (score per \$1M)	Energy intensity — MW required per \$1M invested (MW / \$1M)	Jobs created per \$1M invested (direct + indirect) (jobs / \$1M)	Regulatory risk score (0 = no risk, 1 = very high risk)	Talent readiness score (0 = low, 1 = high)
Mining[22]	7.5	0.33	12	0.6	0.5
Node Hosting (Data centers / validator nodes / hosting)[23]	6	0.043	8	0.2	0.7
Startups (DeFi, apps, fintech startups)[24, pp. 5–9][25, Table 2.4][26, p. 12]	7	0.06	10	0.3	0.65
R&D (Universities, training, grants, talent development)[27, pp. 17–23][28]	5	0.02	18	0.1	0.8
Exchanges (exchanges, crypto services, custodial services)[39, pp. 32–34] [30]31, Table 3.2]	6.2	0.05	6	0.4	0.6

As a result of solving the problem, we found the following optimal distribution:

- Startups (DeFi, FinTech, applications) - about 80% of investments,
- R&D (research and education) - minimum mandatory investment - 10%,
- The remaining directions - Mining, Node Hosting and Exchanges - were not included in the optimal plan due to high energy and regulatory risks.

As a result of this distribution, the maximum value of the objective function was 68.5 points, which represents the peak of the strategic impact of the Armenian blockchain investment portfolio.

A more detailed analysis also showed the sensitivity to resource constraints.

- An increase in budgetary resources by one million dollars increases the strategic impact by about 7 points,
- An increase in human capital by one point increases the value of the objective function by an average of 3.3 points,
- Reducing R&D investments, on the contrary, has almost no effect on efficiency, but has an important structural significance in terms of maintaining the educational base.

The data obtained indicate that the most scarce resource in Armenia's blockchain strategy is financial resources, and the second important factor is the limited potential of human capital.

Conclusions: In summary, this study aimed to quantitatively assess Armenia's strategic position in the global blockchain ecosystem based on a combination of digital infrastructure, innovation potential, and cryptocurrency adoption. Using K-means cluster analysis and Principal Component Analysis (PCA), it was possible to map the distribution of countries within the global digital economy and identify three main clusters: "Global Leaders," "Emerging Integrators," and "New Entrants."

Armenia was classified as an "Emerging Integrator" cluster, demonstrating a high digital infrastructure (0.8) and an above-average innovation index (0.534), but a relatively low level of crypto adoption (0.019). This combination indicates that the country's technological potential is not fully translated into market activity.

The application of the optimization model showed that in conditions of limited financial, energy and human resources, the maximum strategic impact is achieved by focusing investments on the development of startups (about 80%), and with minimal mandatory allocations to the R&D sector (about 10%). The lack of human capital and budgetary constraints have been formed as the main limiting factors of Armenia's blockchain strategy. As a result, the value of the calculated objective function was 68.5 points, which represents the maximum strategic impact of Armenia under conditions of optimal resource allocation.

Speaking about the main results, we will say that

- Armenia is at an average level of blockchain integration, having a stable technological base, but weak market penetration,
- Cluster analysis showed that innovation potential and digital infrastructure are the main advantages of Armenia.
- The optimization model revealed that the most effective investment direction is the development of startups, while the issues of the regulatory environment and human resources are priority areas for improvement.
- Budgetary constraints and the lack of human capital are the most influential constraints on Armenia's blockchain strategy.

The research combines cluster analysis and optimization modeling, which allows not only to quantitatively classify Armenia on the global blockchain map, but also to formulate an optimal resource allocation strategy. This is a new approach in the analysis

of Armenia's digital economy, which fills the existing theoretical and applied gaps. The obtained justifications can serve as a political and practical basis for strengthening Armenia's position in the global digital ecosystem and developing a national blockchain strategy.

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ANALYSIS OF FACTORS AFFECTING THE MARRIAGE RATE IN ARMENIA USING THE REGRESSION METHOD

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Abstract

The purpose of this article is to present and analyze the fundamental components of the demographic situation in the Republic of Armenia, as defined by the main indicators of marriages and divorces. It should be noted that the institution of marriage serves as an important indicator not only of social but also of economic and demographic processes; therefore, an adequate analysis is possible only within the framework of multifactorial observation. The article presents an empirical study of socio-economic and demographic factors influencing the dynamics of marriages, using regression analysis methods. As a result of the analysis, factors that have a statistically significant impact on the formation of the marriage rate were identified. At the same time, a forecast of the number of marriages and divorces for 2024–2027 was developed, allowing for an assessment of possible future developments and trends. The Durbin–Watson test was applied to detect autocorrelation in the time series, leading to the identification of the main patterns and trends.

The findings of the study can serve as a basis for developing policies aimed at strengthening the institution of marriage and family, as well as for improving demographic forecasting.

Keywords: marriage, divorce, regression analysis, prediction, Durbin-Watson criterion, socioeconomic factors, demographic factors.

In modern socio-economic conditions, the study of demographic processes—particularly the analysis of the dynamics of marriages and divorces—plays an important role in ensuring the sustainable development of society. The trends observed in Armenia and worldwide in recent years—such as delayed marriage, the spread of cohabitation, emigration, declining youth employment, and income inequality—are transforming the structure and value system of the traditional family. These changes may have a long-term impact on the country's demographic situation and fertility rate [7,8]. Marriage is a legally recognized, free, and voluntary union between a man and a woman, the purpose of which is the creation of a family, and which establishes mutual personal and property rights and obligations. Under the conditions of socio-economic development in modern society, the statistical assessment of marriage and divorce rates is particularly important, as they are among the key indicators characterizing the demographic situation of a country [5].

Under current conditions, a comprehensive study of the factors influencing the number of marriages, based on statistical and econometric methods, is becoming increasingly relevant. The use of regression analysis makes it possible not only to assess the direction and strength of factor influence but also to develop

forecasting models for evaluating future trends. The research also includes a forecast of the number of marriages and divorces for the period 2024–2027.

To quantitatively assess the impact of various factors on the number of marriages, regression analysis was applied. The essence of this method lies in the fact that, when including the selected factors in the model, the significance of their impact on the dependent variable and the relevance of the results are evaluated at each stage.

The following factors were selected for the regression analysis:

- Y – marriage rate (‰)
- X_1 – divorce rate (‰)
- X_2 – average life expectancy of men (years)
- X_3 – average life expectancy of women (years)
- X_4 – share of men of marriageable age in the total population of marriageable age (%)
- X_5 – sex ratio coefficient (number of men per 100 women)
- X_6 – share of employed persons in the total labor force (%)
- X_7 – housing provision per resident (square meters)
- X_8 – average monthly nominal salary (AMD)

Table 1

Main indicators characterizing marriages in the population of the RA 2000-2023 [1,2,3]

	Y	X ₁	X ₂	X ₃	X ₄ *	X ₅ *	X ₆ *	X ₇	X ₈
2000	3,4	0,4	70,1	75,8	48,1	92	54,2	17,5	22706
2001	3,8	0,6	70	76,1	48,2	92	52,6	17,7	24483
2002	4,3	0,5	69,8	75,9	48,2	92	56	21	27324
2003	4,8	0,6	69,9	75,8	48,5	92	55,1	21,1	34783
2004	5,3	0,6	70,3	76,4	48,6	93	53	21,7	43445
2005	5,2	0,8	70,3	76,5	48,7	93	53	23,1	52060
2006	5,4	0,9	70	76,4	48,9	93	51,7	23,6	62293
2007	5,8	0,9	70,2	76,6	49	93	50,7	26,2	74227
2008	6	0,9	70,4	76,9	49,1	94	49,8	26,3	87406
2009	6,1	0,9	70,6	77	49,3	94	48,1	26,7	96019
2010	6	1	70,6	77,2	49,4	94	49,6	27,2	102652
2011	6,5	1,1	70,7	77,5	48,4	92	51,4	28,3	108092
2012	6,3	1,1	70,9	77,5	48,4	92	51,9	30,9	140739
2013	6,1	1,2	71,5	77,9	48,5	92	53,2	31,3	146524
2014	6,3	1,5	71,8	78,1	48,4	92	52	31,6	158580
2015	5,9	1,2	71,7	78,2	48,4	91	51	31,5	171615
2016	5,5	1,2	71,6	78,3	48,3	91	50	31,4	174445
2017	5,1	1,3	71,9	78,7	48,2	90	50,1	31,9	177817
2018	5	1,3	72,4	76,1	47,9	90	47,7	31,6	172727
2019	5,3	1,3	73,1	76,7	47,8	89	48,9	32,6	182673
2020	4,1	1,1	68,4	72,9	47,6	89	47,8	33,3	189716
2021	5,8	1,5	67,4	71,6	47,5	89	48,9	33,9	204048
2022	5,7	1,5	71,4	74,9	47,4	89	50,9	35,5	235576
2023	5,5	1,5	74,1	77,8	47,5	90	52,8	36,4	269994

The results of the regression analysis show that the values of the multiple correlation and determination coefficients are quite high ($R = 0.934$, $R^2 = 0.873$), indicating a significant influence of the independent variables included in the model on the marriage rate. The

determination coefficient of the resulting model suggests that 87.3% of the variation in the number of marriages is explained by changes in the factors included in the model. Table 2 presents the results of the analysis of variance and the corresponding F-statistic value, confirming the statistical significance of the model.

Table 2

ANOVA

	df	SS	MS	F	Significance
Regression	8	13,38688	1,67336	12,89548	1.87E-05
Residual	15	1,94645	0,129763		
Total	23	15,33333			

Table 3 presents the estimated regression coefficients, their standard errors, t-statistics, and significance levels [4]. The analysis of the parametric estimation results of the linear regression model shows that

the effects of two factors are statistically significant. Therefore, it is advisable to construct a linear regression model including only factors X_1 and X_7 .

Results of the linear regression model estimation

	<i>Coefficients</i>	<i>Standard error</i>	<i>t-statistic</i>	<i>Significance level</i>
intercept	-34,8521	17,78144	-1,96003	0,068841
X ₁	1,44206	0,764076	2,544519	0,02244
X ₂	0,000118	0,124726	0,00095	0,999255
X ₃	-0,0087	0,119796	-0,07265	0,943044
X ₄	-0,02853	0,657702	-0,04339	0,965967
X ₅	0,358797	0,192086	1,867899	0,081438
X ₆	0,053108	0,061279	0,86665	0,399785
X ₇	0,232343	0,086916	2,673184	0,017367
X ₈	-1,5E-05	7,27E-06	-2,04817	0,058467

By including the obtained estimates in the regression model, we will have the following regression equation:

$$Y = -34,852 + 1,442X_1 + 0,232X_7$$

The results of the obtained regression equation can be interpreted as follows: if the divorce rate increases by 1%, the marriage rate will, on average, increase by 1.44%. Similarly, an increase in the population's living area by 1 square meter per person leads to an average increase of 0.23% in the marriage rate.

For a more in-depth analysis of marriages and divorces, as well as for forecasting purposes, it is necessary to identify trends in the dynamics of the number of marriages and divorces using the analytical smoothing method. Figures 1 and 2 present the linear, logarithmic, and second-order parabolic trend lines, along with their corresponding equations and coefficients of determination, which characterize the dynamics of the number of marriages and divorces.

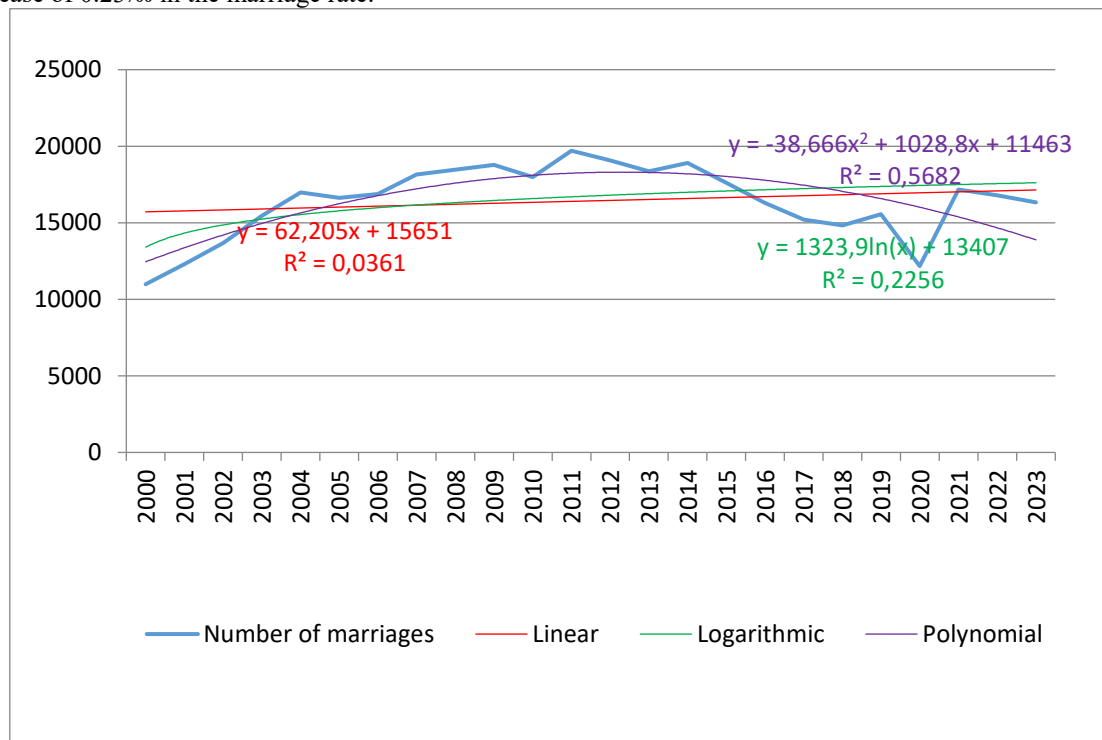


Figure 1. Different types of trends in the dynamics of the number of marriages, 2000-2023.

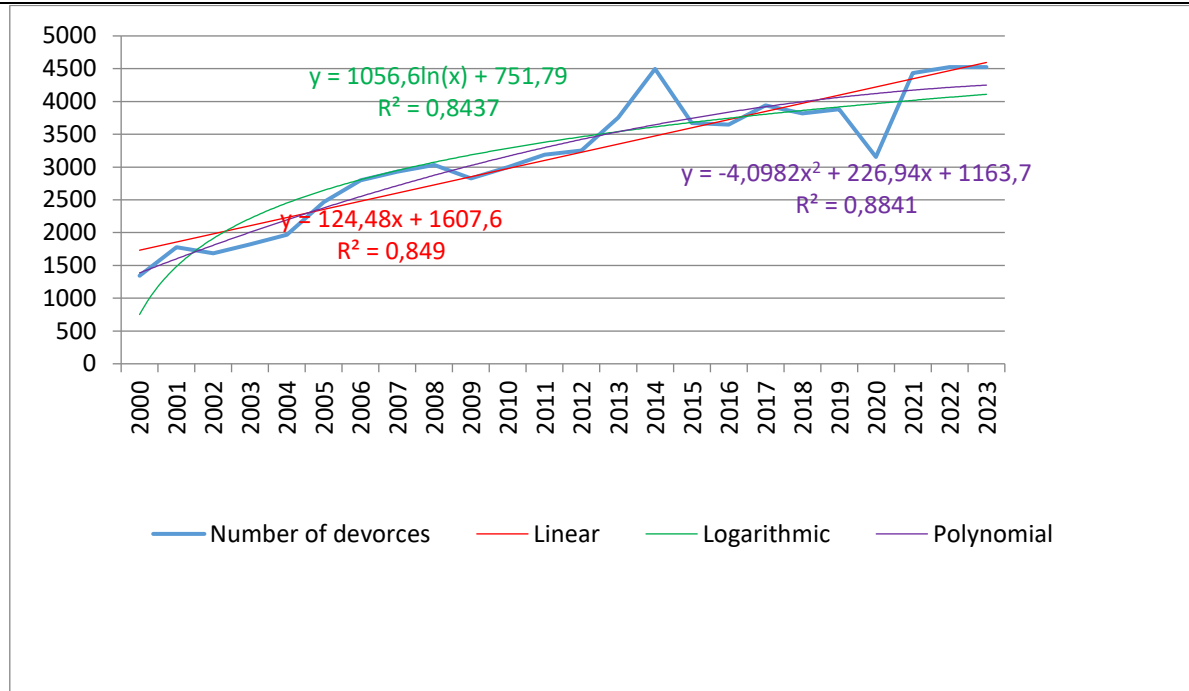


Figure 2. Different types of divorce rate trends, 2000-2023 1

Based on the dynamics of the number of marriages and divorces in the Republic of Armenia, and taking into account the coefficients of determination obtained from the above equations, it is appropriate to select the second-order parabolic function as the trend equation.

For marriages:

$$y = -38,666x^2 + 1028,8x + 11463$$

$$R^2 = 0,5682$$

For divorces:

$$y = -4,0982x^2 + 226,94x + 1163,7$$

$$R^2 = 0,8841$$

If the form of the function is chosen inappropriately, the successive values of the residual series may not exhibit independence, as they can be correlated with one another. In such cases, this phenomenon is referred to as autocorrelation of the residuals.

One of the most commonly used methods for detecting autocorrelation is the Durbin–Watson test. The obtained test statistic is compared with the critical limits determined by the authors of the method, which makes it possible to accept or reject the hypothesis of no autocorrelation in the residual series.

For marriages $DW = 1.90$

For divorces $DW = 1.62$

The obtained values ($DW=1.90$, $DW=1.62$) are compared with the critical limits, which allows us to accept or reject the hypothesis of the absence of autocorrelation in the series of e_t residuals. Let's compare our obtained values with the values $dL=1.046$ and $dU=1.535$. It turns out that the obtained values are greater than the upper limit. Therefore, the hypothesis of the independence of random deviations is not rejected.

Based on the fact that the pattern of development of the phenomenon will be preserved in the future, let's make an extrapolation based on the selected model. The forecast period should not exceed 1/3 or a maximum of 1/2 of the base period. In the case of longer periods, the reliability of the forecast decreases.

The forecast up to 2027 indicates a decreasing trend in the number of marriages and an increasing trend in the number of divorces.

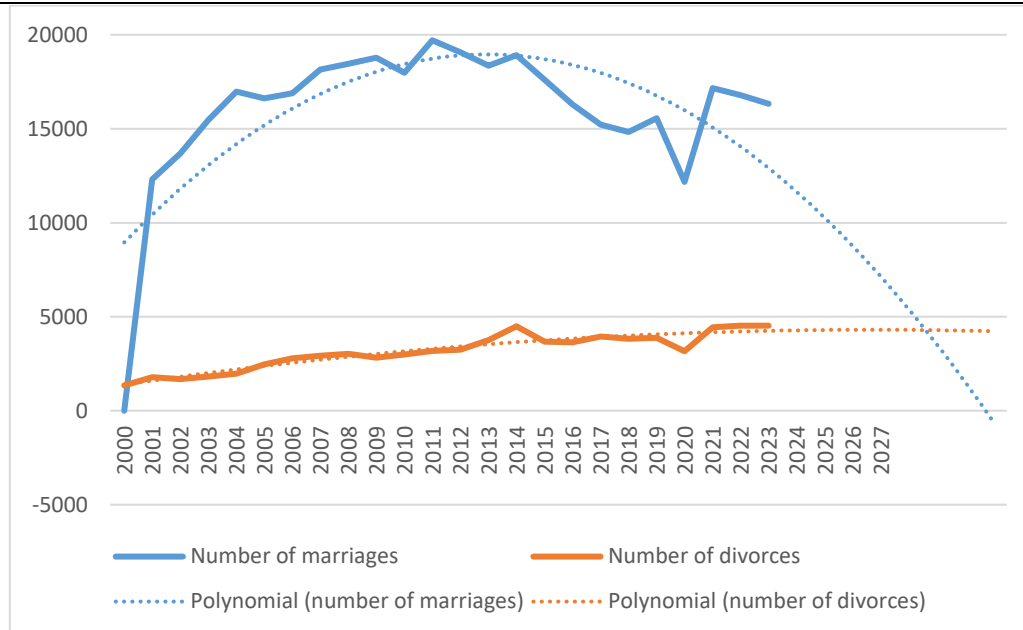


Figure 3. Forecast of the number of marriages and divorces for 2024-2027

The analysis revealed that several socio-economic and demographic factors—particularly the divorce rate and housing availability—have a significant impact on the number of marriages. The use of regression analysis allowed for a quantitative assessment of the strength and direction of these factors' influence, as well as the construction of a forecast model for marriages and divorces for 2024–2027. The forecast results show some fluctuations, but the overall trend indicates that the number of marriages largely depends on socio-economic conditions.

The autocorrelation of the model residuals was examined using the Durbin–Watson test, which confirmed the statistical reliability of the model and the accuracy of the predictions.

Overall, the analysis of marriage dynamics and the identification of influencing factors are important not only for assessing the demographic situation but also for informing social policy [6].

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ANALYSIS AND ASSESSMENT OF THE CURRENT STATE OF FINANCIAL SECURITY INDICATORS

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Abstract

The article identifies the need to create a new system of indicators for national financial security. To prevent financial risks, it is proposed to calculate financial security indicators based on microeconomic indicators. Parameters for national financial security are defined to effectively analyze the state of security in the financial sector. It is concluded that financial security indicators should be grouped according to the sphere of activity and the entities involved in financial security.

Keywords: indicator, financial security, functions, external threats, inflation, macroeconomic and microeconomic indicators, shadow fund, stability, balance.

In accordance with the concept and strategy of the economic security of the Republic of Azerbaijan, the state of the country's economy must meet certain quality criteria and thresholds that ensure acceptable living conditions, the stability of the socio-economic situation, the military-political stability of society, the integrity and ability of the state, and the ability to resist the impact of internal and external threats [8].

The criterion of economic security is an assessment of the state of the economy in terms of the most important processes that reflect the essence of economic security. The assessment of security based on the criteria includes the assessment of the following:

- resource potential;
- the level of resource efficiency;
- economic competitiveness;
- territorial integrity and economic space;
- independence and the ability to resist external threats;
- the idea of sustainable development, which consists in achieving a balance between social stability and factors preventing social conflict, the needs and capabilities of society.

The security of the financial system has a significant impact on the country's economy. Financial security is a mechanism of economic relations that creates high-quality conditions and the necessary financial resources for expanded reproduction, increased entrepreneurial activity and solvency of the population, maintaining balance and integrity of the state financial system, effectively combating internal and external threats to the state in the financial sector. However, such a definition does not fully explain the structure and list of indicators that comprehensively characterize the current state of the country's financial security.

Financial security indicators should characterize the dynamics of economic systems. Not only the indicators themselves are important to ensure financial security, but also their threshold values. When we say these threshold values, we mean such levels of thresholds that their failure to meet them prevents the sustainability of expanded reproduction and ultimately leads to the emergence of negative trends in the socio-economic sphere. As a result of deviation from these threshold values, the national economy loses its ability

to develop dynamically, loses its competitiveness in foreign and domestic markets and becomes a target for the expansion of monopolies.

A critical condition for ensuring economic security is monitoring the dynamics of economic security indicators based on the analysis of specific quantitative values of these indicators, exceeding which poses a threat to the economic security of the state.

The activity of the state financial security structure ensures the budget, tax, monetary and credit, investment, insurance, customs, currency, debt policy.

The formation of a system of indicators occurs at the legislative level of the state. Financial security indicators are structural elements that reflect the process itself or the state of the analyzed object, as well as its quantitative and qualitative characteristics. Financial security indicators perform the following main functions:

- forecasting events that may occur in the near future;
- analysis of the situation and possible warning of unforeseen circumstances;
- analysis of the security situation in the financial sector of individual objects;
- operational implementation of various adjustments in the process of development of the financial sector by state administration.

The system of indicators, fulfilling its functions, is the main tool for diagnosing the state of the country's financial system. The values of financial security are developed for each specific country on the basis of macroeconomic indicators reflecting its fundamental national interests.

Analysis of the state of security in the financial sector should be carried out using indicators determined in the economic strategy of each specific state, taking into account the following parameters:

- stability of financial flows at all levels of the financial system;
- fulfillment of tax obligations (debt);
- level of cash and non-cash payments in the payment system;
- speed and value of the money supply;
- volume of reserves (their size, ratio to GDP and state debt);

- GDP (its change over 5-10 years and per capita);
- trade (trade balance, exports, imports).

It should be noted that in order to determine the presence of threats to the financial security of the state, it is necessary to determine the acceptable threshold for indicators. The threshold is understood as a numerical measure, non-compliance with which will lead to a decrease in the efficiency of economic processes and the formation of negative situations in the country's financial system. However, approaching the thresholds of financial security is a factor confirming the increase in negative trends in this area. The fact that indicators exceed the permissible limits indicates a threat to the state financial confirms the fact of violations in the functioning of the financial system.

Financial security indicators should be combined into the following groups depending on the field of activity:

- investment,
- money and credit,
- budget,
- tax,
- insurance,
- currency,
- social.

Financial security should be assessed using indicators characterizing the results of the activities of the following financial security entities:

- state bodies,
- enterprises,
- households,
- population.

The assessment of security indicators in the financial sector of the Republic of Azerbaijan is characterized by the following indicators:

- inflation rate,
- level of monetization of the economic environment,
- average annual growth rate of GDP,
- profitability of the economic sector in the regions,
- changes in structural elements,
- volume of demand for money circulation,
- supply in the economic environment.

The financial security indicators we have mentioned indicate the conditions for the functioning and efficiency of the state's economic environment. Analyzing the above indicators of the country's financial security, we can identify external threats that may affect the security of Azerbaijan in the financial sphere.

The main threats may include:

- increased competition between countries in the financial sector, as well as in other areas;
- active growth in the capitalization of financial assets;
- dependence of the Azerbaijani economy on foreign investments;
- globalization.

Along with external conditions that may lead to a crisis in the Azerbaijani economy, there are also internal indicators that significantly affect the country's financial security. Let's give one of the internal indicators:

- activity of the shadow fund;
- weakening of the regulatory function of the financial system in the field of budget formation and execution at all levels;
- increase in inflation.

In ensuring the financial security of the state, special importance is attached to priority areas for reducing the level of inflation, the consumer price index, and increasing the solvency of the population. These priority areas should be determined by the state mechanism that ensures the effective functioning of the state financial system at the legislative level. The state mechanism for ensuring the financial security of the state is a functional complex of state bodies and institutions that create conditions for the stable functioning and balanced development of the state financial system, as well as for predicting, detecting, preventing and combating threats to it.

This mechanism includes the following components:

- legislation - a set of regulatory and legal acts in the field of preventing external and internal threats to financial security;
- institutional - a system of state authorities and management bodies ensuring the financial security of the state;
- Methodological - a set of tools and methods for ensuring financial security.

Detailed regulation of the state mechanism is the main condition for the stable and balanced functioning of the state financial system and the high quality of the existing regulatory and legal framework. The system for determining the state financial security indicators should be integrated into the state mechanism as a prerequisite for ensuring the financial security of the country and should operate on the basis of the following principles:

- legality (indicators should be calculated only in accordance with the current legislation);
- reliability (all components of the indicator system should be based on a single methodological base);
- consistency (indicators should be calculated in stages, taking into account priorities);
- stability and reliability.

Summing up the analysis of the financial security indicators of Azerbaijan, it can be concluded that there are deviations from the threshold values of a number of indicators. To improve financial security, attention should be paid to improving both economic and social indicators and at the same time adjusting these indicators to the appropriate threshold values. In order to create a functioning economic structure that meets the requirements of the market, the government should determine its priorities in all areas, including at all levels of society and the economy.

Thus, in modern times, ensuring the financial security of the state is the most important direction for stabilizing economic processes. However, in order to ensure financial security in the country at a time when the threat of new conditions emerging in the world is increasing, it is necessary to develop a new system of indicators of state financial security. The new system of

indicators of state financial security should be calculated not only on the basis of macroeconomic indicators, but also on the basis of microeconomic indicators. Indicators calculated based on microeconomic indicators of territorial development d It will allow for the prompt and reliable identification of priority ways to prevent financial risks, taking into account the impact of internal and external threats.

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CAN ARTIFICIAL INTELLIGENCE CHANGE OUR LIVES, AND HOW?

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Assistant Professor, GTU***Chikovani E.***Doctor of Business Administration***Sharashidze L.***Senior Visiting Lecturer, Batumi Shota Rustaveli State University*<https://doi.org/10.5281/zenodo.17608958>**Abstract**

Information and communication technologies (ICT) are a rapidly developing and growing field, which, in the era of the Fourth Industrial Revolution, digital transformation plays a special role in shaping the global agenda, world economic events, social development, public administration, and management. For a modern person, regardless of their interests or work style, adapting to the digital world and acquiring and improving skills for it is a vital factor. Do we need to use technologies in the process of implementing public governance? The answer to this is unequivocal: modern challenges require making modern decisions by maximizing the use of existing opportunities. The public sector of any developed country, in the process of digital transformation, should actively learn about and explore new technologies, modern innovative achievements, and strive to use these technological innovations to increase the efficiency, effectiveness, accountability, and openness of the public sector, and offer user-oriented, reliable, and trustworthy services to the information society.

Keywords: Artificial intelligence, digital governance, digital transformation, innovative achievements.

Introduction

Modern challenges require the maximum use of existing capabilities to make modern solutions. The public sector of any developed country in the process of digital transformation should actively familiarize itself with and explore new technologies, modern innovative achievements, and try to use these technological innovations to increase the effectiveness, efficiency, accountability, and openness of the public sector and offer user-oriented, reliable, and trustworthy services to the information society.

“Digital” is not only a term denoting technology, but also defines what ICT can do through technological transformation of socio-economic processes and various fields. “Digital transformation” implies new ways of solving problems, creating unique experiences, and improving business processes.

Today, there are already technological solutions that will completely change our lives. What are these technologies? Eight technological solutions have been recognized globally in this way, among which artificial intelligence (hereinafter referred to as “AI”) takes the lead. In the modern world, interest in artificial intelligence is growing rapidly. International news media outlets devote a considerable amount of space to the topic of artificial intelligence. Leading world politicians and researchers are increasingly discussing AI and its implications for humanity's future in their debates. Over the past five years, scientists, researchers, activists, and policymakers have become increasingly interested in artificial intelligence technology.

This article aims to provide the reader with information about the main aspects of artificial intelligence, not only as a technological solution, but also as a completely different methodology for

developing business/public administration processes, a modern tool for decision-making, management, and supervision.

Discussion

Artificial intelligence is a product of the digital transformation, the fourth industrial revolution. Artificial intelligence is a field of computer science, a specialized and advanced type of ICT, that performs intellectual actions typically characteristic of humans. Automated decision-making processes/systems that imitate, predict, and/or replace human behavior. The Council of Europe defines artificial intelligence as: “a set of sciences, theories, and technologies that aim to reproduce human cognitive abilities by a machine. Given the current level of development, artificial intelligence means delegating complex intellectual tasks that humans should perform to a machine.”

1. According to the definition developed by the European Commission High-Level Expert Group (AI HLEG), “Artificial Intelligence characterizes systems that, by analyzing the environment, exhibit intelligent behavior and, with a certain level of independence, perform actions to achieve specific goals.

2. Human-like abilities characteristic of artificial intelligence are: perception, argumentation, reasoning/evaluation, and action, with the exclusion of the human factor/with minimal interaction.

When defining artificial intelligence, several concepts are distinguished: narrow, general, and super artificial intelligence. Examples of narrow artificial intelligence are the most widespread today - these are technological solutions created for specific tasks, to perform single tasks. Nowadays, the development of artificial intelligence and its prosperous future are inconceivable without human efforts and intervention. In conditions of general artificial intelligence, the

capabilities of humans and technology are equalized. We can consider unmanned control systems as such a case. Artificial superintelligence is still only an imaginary product. This is the scenario in which artificial intelligence will surpass human capabilities. And will be able to act/make decisions better, more correctly, and faster than they do, whether computer capabilities have equaled human capabilities or not, whether they have surpassed human thinking. These issues remain the subject of ongoing research and evaluation. Using artificial intelligence, a person should be able to solve difficult, complex problems in the shortest possible time and with maximum accuracy, as well as fully delegate simple tasks.

Artificial intelligence, by collecting, processing, and analyzing a large amount of digital information, helps us find the desired information as quickly as possible, without human effort, and based on objective criteria. It also analyzes similar data and makes the most rational decision statistically.

Two main characteristics define Artificial Intelligence:

- **Autonomy:** the ability to perform tasks in a complex environment, in the presence of many variables, without constant control/supervision by the user.
- **Adaptability:** the ability to (self)learn and improve results based on experience.

The existence of appropriate prerequisites is required for the implementation of artificial intelligence in any country. Firstly, it is essential to have a highly developed ICT infrastructure and widespread use of digital governance, ensuring the proper functioning of interoperable databases and information systems, which unconditionally guarantee data quality, integrity, and accessibility. Additionally, sound and documented business processes must be employed in both departmental and inter-organizational transactions. Databases must be digitized and accessible, and the information and data within them must be complete, accurate, and up-to-date. The information/data in the databases must be complete, correct, and up-to-date.

By utilizing prerequisites, creating enabling tools and frameworks, and leveraging artificial intelligence, successfully implemented initiatives will yield economic growth, enhanced social well-being, improved public services, and effective public administration.

There is a growing global trend in the use of artificial intelligence in the public sector. In several countries, specialized public structures have already been established to develop this direction. For example, the United Kingdom and the United Arab Emirates, where, respectively, the Artificial Intelligence Service and the Ministry of Artificial Intelligence have been established.

The use of artificial intelligence enhances the process of providing public services, improving the quality of services (government-to-government (G2G), government-to-business (G2B), and government-to-citizen (G2C) services). With artificial intelligence technological solutions, the provision of public services

is improved, citizen involvement in the decision-making process increases, and ultimately, we achieve a more responsible, accountable, transparent, and efficient public sector.

Developed countries are most actively using artificial intelligence in the following areas:

- Improving governance processes and public sector activities using algorithms; Modernizing public policy;
- Automating business processes in public agencies, updating document management and case management systems;
- Stimulating innovative projects in the public sector;
- Providing state e-services and enhancing citizen engagement, including offering proactive and personalized services.

Artificial intelligence is most actively used to solve the following public tasks:

- **Enforcement:** enforcing legislative and regulatory requirements, monitoring, and inspection.
- **Public policy research, analysis, monitoring:** based on evidence and data
- **Decision-making process support.** Analysis/argumentation based on existing cases (Case-based Reasoning), making new decisions based on existing data and previous cases.
- **Public services and engagement:** improving the delivery of public services focused on citizens and business entities, personalizing services, understanding the meaning of information using logical-deductive methods, and simplifying the search for such information; finding and offering personalized public services tailored to the priorities and needs of citizens.
- **Subsidization, granting social assistance:** identifying specific target groups eligible for social assistance.
- **Internal document circulation systems:** supporting organizational management systems (human resources, procurement, ICT systems).

In the modern world, both developed and powerful economies, as well as developing and resource-poor states, are recognizing the potential of modern data-based technologies and actively utilizing artificial intelligence to automate public tasks, make informed decisions, and improve citizens' experiences of interacting with public institutions. Artificial intelligence offers the public sector several significant opportunities, including:

- **Efficiency:** Doing more and more important things: new opportunities, increased capabilities, concentration of human resources from bureaucracy to highly intellectual work, and reduction of the risk of human errors.
- **Optimization:** Doing better: reducing costs, maximizing human and time resources, speed, quality, flexibility, exercising public authority at a high level of quality, quickly and cheaply. Repetitive and laborious tasks that can be monotonous and boring for people are delegated to technology.
- **Increased value:** Renewed business models: engagement, creativity, innovation.

Let's examine the essential decisions, legal frameworks, and strategic approaches proposed by various international authors.

The European Union: The world community and global leaders recognize that a country developed with artificial intelligence enjoys a significant competitive advantage in the international arena. The European Union states that it has no competitors today in the implementation of human-oriented artificial intelligence, which supports human rights and freedoms, the rule of law, and the principles of democracy. The use of artificial intelligence is subject to the requirements of the international legal framework. In this regard, the European Union, along with other global players, plays a leading role. Various institutions within the European Union, including the European Commission, unequivocally support the use of artificial intelligence and encourage its large-scale implementation, providing financial support for this endeavor.

The **USA** remains the largest, most extensive, and influential research hub in the field of AI. Approximately 3,000 students study and research artificial intelligence annually, with over 1,400 startups, and 7 of the world's 10 largest AI companies operating in this field. All this, with many years of collaborative experience of the above-mentioned research centers, universities, companies, and public structures, clearly establishes the USA as a global leader in AI.

China: China is a serious competitor to the USA for world leadership in artificial intelligence. By 2030, it aims to achieve global dominance through its strategic plan, recognizing artificial intelligence as a key strategic advantage in the knowledge economy. China is the only country that measures the development of artificial intelligence using macroeconomic indicators.

South Korea is focused on finding and retraining AI talents, strengthening the research component, and collaborating on projects between the science and economic sectors.

EU Member States and the UK: The EU Member States have developed the most comprehensive strategies for the development, regulation, and management of AI; almost all EU Member States have established a strategic framework and action plan for the development of AI.

France's AI Strategy: The primary emphasis is on research and the creation of targeted groups that will study specific issues and prepare recommendations.

Germany: Germany has created a fairly comprehensive legal framework on responsibilities, rights, and accountability when using AI (especially in the case of self-driving cars). For example, discrimination against citizens during an incident is prohibited. Germany has an Ethics Commission for Self-driving Vehicles, which issues guidelines. A national commission has also been established to examine the social implications of algorithmic decision-making.

UK: The UK House of Lords and the Office of the Information Commissioner are actively working on AI

issues. The House of Lords focuses on the perception of AI algorithms, while the Data Protection Commissioner conducts research and develops recommendations for establishing a regulatory and legal framework. Additionally, the UK plans to invest significantly in AI within the educational sector.

Finland has also established a high-level expert group on AI, whose purpose is to study the conditions for developing an innovative AI market within the country.

Denmark: Denmark views AI in the context of the country's "digital growth and development." Encouraging data openness, easing regulations, creating a flexible legal environment, and strengthening cybersecurity are the country's approaches to AI development.

Sweden: Sweden's AI strategy focuses on four main areas: education and training, research, innovation and application, and frameworks and infrastructure.

Italy: The main public policy document on AI, "Artificial Intelligence at the Service of the People," encourages the public sector to use AI.

Spain: The Spanish government is examining the economic sectors in which AI can be applied, the potential social impact on the labor market, and the empowerment of individuals through this technology.

Artificial Intelligence and Georgia

In Georgia, examples of artificial intelligence can be found in both the public and private sectors. Although the issues of their functioning and development are addressed within a narrow organizational context, the compatibility of these private cases would be required for any of these applications. Several examples of the use of artificial intelligence in the public sector are publicly available; these are:

- A risk management system to be used when implementing customs control over goods declared on the customs territory of Georgia through the automated customs data system "ASYCUDA". During the customs clearance process, if the data of the declared goods matches the risk criteria, the appropriate corridor and customs clearance procedure are determined for the declaration registered in the system. The Revenue Service intends to utilize chatbots in the tax and customs consultation process. Also important is the system for automatically refunding VAT excess.

- The campaign of the National Tourism Administration of the Ministry of Economy and Sustainable Development to analyze the impressions expressed by tourists about Georgia on social media using artificial intelligence.

- Analytical software for recognizing faces of individuals and recognizing the state license plate of a vehicle by the Ministry of Internal Affairs of Georgia.

Modern technologies, including artificial intelligence, cannot become a positive influence and a prerequisite for public welfare if the state does not ensure the implementation of digital transformation reforms with high ethical principles, maintain a balance of conflicting interests, involve all stakeholders, taking into account best practices and international regulatory

standards, transparent procedures, and a transparent management system.

Services supported by artificial intelligence can bring numerous benefits to humanity. With the large-scale adoption of this technology in the public and private sectors of Georgia, we can expect to see a proven indicator of effectiveness, efficiency, resource conservation, and high productivity. For this, along with technological readiness, it is crucial to establish a supportive framework and gain the public's trust.

The Georgian public sector should actively promote the use of modern technologies, including artificial intelligence, both within its own institutions and on a national scale. Georgia should utilize the benefits of artificial intelligence in a timely and effective manner, so as not to significantly lag behind the economic and social transformation inspired by this technology, and not lose the benefits provided by this process.

Conclusion

Today, there are already technological solutions that will completely change our lives. What are these technologies? Eight technological solutions have been recognized in this way worldwide, among which artificial intelligence (hereinafter referred to as "AI") takes the lead. We believe that

Artificial intelligence is a product of digital transformation, the fourth industrial revolution. Artificial intelligence is a field of computer science, a special, developed type of ICT that performs intellectual actions that, as a rule, are characteristic only of humans. Automated decision-making processes/systems that imitate, predict, and/or replace human behavior. The Council of Europe defines artificial intelligence as: "a set of sciences, theories, technologies, the aim of which is to reproduce human cognitive abilities by a machine. Given the current level of development, artificial intelligence means delegating complex intellectual tasks to a machine."

The implementation of artificial intelligence in any country requires the existence of appropriate prerequisites. Firstly, it is essential to have a highly developed ICT infrastructure and widespread adoption of digital governance, ensuring the proper functioning of interoperable databases and information systems. This guarantees the quality, integrity, and availability of data, as well as the use of sound and documented business processes.

In Georgia, modern technologies, including artificial intelligence, cannot become a positive

influence and a prerequisite for public welfare if the state does not ensure the implementation of digital transformation reforms with high ethical principles, maintain a balance of conflicting interests, involve all stakeholders, taking into account best practices and international regulatory standards, transparent procedures, and a transparent management system.

Services supported by artificial intelligence can bring numerous benefits to humanity. With the large-scale adoption of this technology in the public and private sectors of Georgia, we can expect to see a proven indicator of efficiency, effectiveness, resource conservation, and high productivity.

The public sector in Georgia should actively promote the use of modern technologies, including artificial intelligence, both within its own institutions and on a national scale. Georgia should use all the benefits that accompany the introduction of artificial intelligence in a timely and effective manner.

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HISTORICAL SCIENCES

THE ROLE OF THE GEORGIAN CHURCH IN STATE LAWMAKING ACCORDING TO ANCIENT LEGAL MONUMENTS

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Abstract

In the 4th century, when King Mirian, through the efforts of Saint Nino, declared Georgia a Christian state, from that day forward, the Georgian Church assumed a special and leading role in state affairs. In addition to safeguarding the Christian faith of the nation, the Georgian Orthodox Church made substantial contributions to the country's education and science. According to ancient ecclesiastical legislative collections, the Georgian Church was engaged in a wide range of state activities. A notable example is the Church's invaluable contribution to the creation of ancient legal codes, developed in cooperation with the kings. These old laws, preserved in the form of decrees from ecclesiastical councils, provide insight into the Church's role in the state system of that era.

Keywords: Georgian Church, theology, Orthodox

In the IV century, when King Mirian declared Georgia a Christian kingdom through the efforts of Saint Nino, the Georgian Church assumed a primary and exceptional role in the life of the State. It shaped the spiritual, religious, and ethical norms of the nation. Its strength and influence were closely linked to the country's social and cultural development. As Ivane Javakhishvili notes in his work, the Church "was not merely a sacred ecclesiastical institution, but also possessed characteristics of a state body."²

The Georgian Orthodox Church, alongside protecting Christian faith, contributed significantly towards furthering progress of education and science in Georgia. From the IV century onwards, theological-philosophical and translation schools operated in Georgian monastic centers both within Georgia and abroad.³ As the scholar Korneli Kekelidze writes, "Monasteries created fertile ground for the development of literature and supported its growth. They were centers of cultural and literary activity."⁴ He adds that those who taught at these monasteries were not only theologians, but also philosophers who bridged religious thought with classical knowledge, and were well-versed in grammar, arithmetic, geometry, astronomy, music, jurisprudence, and medicine. He also notes that in those educational institutions (monasteries), the instruction was carried out by philosophers who understood the nature of God and religious belief. These philosophers, according to Korneli Kekelidze, were also theologians—meaning they were members of the clergy—who possessed not only theological expertise but were also highly educated in grammar, arithmetic, geometry, astronomy, music, jurisprudence, and medicine.⁵ It was precisely this broad and rigorous education of the clergy that formed the foundation for Georgia's social and cultural

development. Such a comprehensive intellectual formation among the clergy laid the foundation for Georgia's cultural and social progress.

According to ancient ecclesiastical legislative collections, the Christian Church of Georgia, beyond its educational mission, also engaged in significant state affairs. A key example is its invaluable contribution to legal codification in partnership with the monarchy, as reflected in the formation of several landmark legal texts: the "Writing of the Law Code" (ძეგლის წერა), a foundational legal compilation produced by the Ruis-Urbnisi Council (რუის-ურბნისის საეკლესიო კრება, 1103–1104), commonly rendered in English as "Compilation of the Statute", the "Enactment of the Code by King George" (ძეგლის დადება მეტოქის გიორგის მიერ), the "Council of Chulevi" including the Laws of Bagrat Kurapalates, Beka, and Aghbugha (ჭულევის საკანონმდებლო კრება, ბაგრატ კურაპალატის, ბექასა და აღბუღას კანონები), the "Penal Code" (მცნებები სასჯულო), the "Code of the Catholicoi" (სამართალი კათალიკოზთა), and the "Law of Vakhtang VI" (სამართალი ბატონიშვილი ვახტანგისა), among others. These legal monuments, preserved in the form of "ecclesiastical synods", primarily originated within the Church. They incorporated both canonical law and various branches of secular law—criminal, civil, administrative, and procedural law. They also prescribed rules for judicial appointments and responsibilities. Ancient legal texts also list offenses against the Church, such as blasphemy, violation of religious laws, and heresy—including the destruction of sacred sites or items, and denouncing the

² Javakhishvili, Ivane. *Collected Works in Twelve Volumes*. Vol. VI, p. 67. Tbilisi: Metsniereba Publishing, 1982.

³ Georgian Orthodox Church Library. *History of the Georgian Church*. Available at: <http://library.church.ge>

⁴ Kekelidze, Korneli & Baramidze, Akaki. *History of Ancient Georgian Literature*. Tbilisi: Tbilisi University Press, 1987, p. 35.

⁵ Ibid., p. 34.

faith. Punishment was determined by the “Great Canon of the Faith” (დიდი რჯულის კანონი).

In these legal monuments, the Catholicoi are mentioned as equals to the king. Their superiority among state officials is evident in the canon laws of the Council of Chulevi, particularly in the so-called “Laws of Bagrat Kurapalates, Beka, and Aghbugha,” which represent Georgia’s legal tradition from the IX–XIV centuries and were later incorporated into the legal code of Vakhtang VI. Articles 101, 102, and 103 state that a bishop, priest, or nun could not be punished—regardless of their offense—by the Atabeg. Ivane Javakhishvili writes that if this law had been authored by Atabeg Aghbugha or by the king of that time, it would not have granted the clergy such extraordinary privileges. Therefore, he concludes that these three articles must belong to a time when the clergy held dominant authority in Georgia—when ecclesiastical power stood above secular governance.⁶ Since the full text of the “Laws of Bagrat Kurapalates, Beka, and Aghbugha” has not survived, Javakhishvili suggests that these articles were likely extracted from a legal code originally composed for the entire kingdom and not solely for Samtskhe-Saatabago.⁷

Thus, the legislation placed both secular and ecclesiastical authorities on equal footing—meaning that the king and the Catholicos held equivalent authority in medieval Georgia. For example, the “Code of the Catholicos” strongly condemned opposition to episcopal authority by nobles, gentry, or peasants. Article 17 of that code declares: “Whoever opposes or insults the Catholicos or bishop, or unjustly defames a priest... shall be excommunicated.” In Vakhtang VI’s code, the Church is likewise described as omnipotent and inviolable: Article 25 states, “One rules over the body, the other over the soul.”⁸ This equality of powers helped enable clergy to contribute directly to royal lawmaking, where legislation was infused with high spiritual and moral values. For example, Bagrat Kurapalates’ legal code (IX century), later incorporated by Beka and Aghbugha into their own (XIII–XIV centuries), includes the following phrase: “The law was jointly developed before the kings by bishops, nobles, and wise men, created by divine providence.”⁹ This clearly refers to a working group composed of ecclesiastical and secular figures. It is evident that bishops, as part of the Church hierarchy, participated in developing these laws alongside nobles. Some articles pertained specifically to ecclesiastical matters.¹⁰ Some younger scholars argue that the “wise men” mentioned in the code were legal scholars—early jurists. According to this interpretation, Georgia already had trained legal experts in the IX century. Javakhishvili affirms that these “wise men” were what he calls “experts in state affairs”—that is, jurists knowledgeable in the practical application of law.

A jurist is a legal scholar who evaluates the extent to which a law responds to society’s needs and challenges. Based on this, we can reasonably infer that the “wise men” participating in the aforementioned law-making working groups, as mentioned in Bagrat Kurapalates’ code, were a circle of legally educated individuals who acquired knowledge in civilized countries of that period. Such education, from the early feudal era onward, was primarily received in Georgia by members of the clergy. As previously cited from Korneli Kekelidze’s work, the scholar explains that theologians were also philosophers who, in addition to their broad education, had a solid command of jurisprudence. Based on this, we may confidently infer that the “wise men” referred to in Bagrat Kurapalates’ code were in fact a distinct circle of legally educated clergy who took part in the legislative process. For instance, the introductory section of the XIV-century Council of Chulevi also refers to clerical lawmakers: “I, Atabeg-Amirspasalar Aghbugha, informed the honorable bishops and my uncles, the fathers of Safara, and the bishops and monks from Tao, Shavsheti, and Klarjeti—those entrusted to God and the Holy Mother of God.”¹¹ In modern terms, this means that Atabeg Aghbugha convened bishops from the region of Samtskhe, especially from Tao, Shavsheti, and Klarjeti. Special importance was placed on the clergy of Atsquri and Safara, along with other invited clerics. From the secular side, heads of governmental households and local senior officials were also in attendance.¹² Another notable example is the 16th-century Church Council, whose rulings are known in Georgian legal history as the “Code of the Catholicos.” In response to widespread criminal unrest in the country, this code was compiled solely by ecclesiastical authorities. The “Code of the Catholicos” had legal force and was binding for Georgian society at the time.

The Church’s legislative involvement is further exemplified in the legal compendium of Vakhtang VI, which the king ordered to be compiled by the renowned scholar, Catholicos-Patriarch Domenti IV, as well as Archbishop Grigol, other metropolitans, bishops, and clergy.¹³ These clerics consulted legal codes from foreign traditions and presented them to the royal court, where they were reviewed together with the king in an advisory council and ultimately approved.

Historically, Georgia maintained a tradition in which ecclesiastical and civil legal systems were intertwined over the centuries. Church-related issues and canon law were viewed as integral to state law. For example, the Ruis-Urbnisi Council addressed matters that were religious, legal, historical, and political in nature. It dealt with rules concerning the clergy, the moral conduct of the laity, marriage, and religious rites—all of which were regarded as state-level concerns.

⁶ Javakhishvili, Ivane. *Collected Works in Twelve Volumes*. Vol. VI, p. 88. Tbilisi: Metsniereba Publishing, 1982.

⁷ *Ibid.*, pp. 88–89.

⁸ Metropolitan Anania Japaridze. *Collection of Georgian Ecclesiastical Canons*. Tbilisi: Sakartvelos Matsne Publishing, 2017, p. 227.

⁹ *Ibid.*, p. 222.

¹⁰ *Ibid.*, p. 221.

¹¹ Georgian National Academy of Sciences. *Georgian Encyclopedia*, edited by the Abashidze Scientific Editorial Board. Available at: <https://georgianencyclopedia.com>

¹² Metropolitan Ananias Japaridze. *Collection of Georgian Ecclesiastical Canons*. Tbilisi: Sakartvelos Matsne Publishing, 2017, p. 180.

¹³ *Ibid.*, p. 217.

Today, Georgia's legislative body is the Parliament, consisting of 150 deputies. A legal committee is responsible for drafting bills, which are then presented at parliamentary sessions and, if adopted by majority vote, enacted into law. Medieval Georgia's royal court—the darabazi—played a similar legislative role.

According to Ivane Javakhishvili, the darabazi was the highest organ of government in its time. It was composed of a "Council of Four Clerics": The Catholicos-Patriarch of All Georgia, the Catholicos of Abkhazia, the Chqondideli-Mtsignobartukhutsesi (chief scribe and chancellor), and the chief confessor. These four senior church leaders had exceptional authority within the royal council. All of this is recorded in the "Regulations of the Royal Court," which describes the structure of the Georgian monarchy and the duties of its officials. These high-ranking clerics, much like the legal committee of a modern parliament, would present draft legislation to the darabazi, where it would be deliberated alongside state representatives and approved if deemed acceptable.

The governing legal Council was composed of the highest ecclesiastical hierarchy, while the darabazi was made up of influential figures from both the Church and the state. Its members, known as darbaiselebi—that is, "deputies"—included abbots of monasteries, viziers serving under the chief scribe, provincial governors (Eristavi), and legal scholars described as "experts in state affairs." This hierarchical assembly held the authority to create binding law. The proceedings of the council were overseen by the king, who issued directives on how it should be conducted.¹⁴

To draw a clearer comparison, one could liken the darabazi to a modern legislative body (parliament) and the ecclesiastical lawmakers to today's parliamentary legal committee composed of deputies.

The above examples represent just a small part of a vast historical record, but they are enough to demonstrate that the ancient Georgian legal tradition—preserved in the resolutions of Church councils—offers a clear picture of the Church's role within the state system of that time.

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THE NATURAL AND GEOGRAPHICAL ENVIRONMENT AND STONE AGE SITES OF THE GUZAR DISTRICT, SOUTHERN UZBEKISTAN: THE DISCOVERY OF THE BUTABULAK 1–6 AND CHUCHUKBULAK COMPLEXES

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Abstract

This paper presents new data on the Stone Age of the Kashqadarya region in southern Uzbekistan, focusing on recent discoveries in the Guzar district. Fieldwork conducted in 2023–2025 revealed several open-air lithic workshop sites (Butabulak 1–6) and a Neolithic settlement (Chuchukbulak). These sites are located in a favorable natural setting with ancient river terraces and accessible raw material sources. The finds demonstrate the high archaeological potential of the region and provide evidence for cultural continuity from the Late Palaeolithic to the Neolithic. The results contribute to a better understanding of prehistoric human adaptation and settlement patterns in southern Uzbekistan.

Keywords: Kashqadarya region, Guzar district, Butabulak, Chuchukbulak, Stone Age, Paleolithic, Neolithic, Uzbekistan

Located in the heart of Central Asia, the territory of Uzbekistan stands out for the remarkable diversity of its Stone Age cultures. Nevertheless, some regions of the country—despite their significant archaeological potential—have long remained insufficiently explored. A striking example of this is the Kashkadarya region, particularly its mountainous and foothill zones, as well as the areas surrounding natural springs [Turg'unova, M. S. (2020). The study of the history of the Stone Age in Uzbekistan. *European Journal of Research and Reflection in Educational Sciences*, 8(11), 113–118].

From a physical-geographical perspective, the Kashkadarya basin represents one of the key natural and geographical units of southern Uzbekistan. It is bordered by the foothills of the Hisor Range to the north and the Karshi deserts to the south. The Karshi oasis, situated between these two contrasting environments, has historically served as a transitional ecological zone favorable for early anthropogenic processes. The archaeological sites analyzed in this paper—Butabulak 1–6 [Muhammadiyev, A., & Brunet, F., 2024] and Chuchukbulak—are located in the Guzar District, in the southwestern part of the oasis, encompassing ancient river systems, alluvial plains, and piedmont zones.

Geographical Location

The Guzar District is located in the southern part of the Kashkadarya region, approximately between 38°30'–39°10' N latitude and 66°20'–66°50' E longitude. Its northern boundary adjoins the foothills of the Hisor Mountains, while the southern part merges with the Karshi Plain. The topography gradually rises from west to east, which influenced the formation of ancient riverbeds and the positioning of prehistoric settlements along fluvial terraces.

Hydrological Features

The main watercourse of the region is the Kashkadarya River, fed by tributaries such as the Guzardarya and Katta Uradarya. These rivers are mainly supplied by snowmelt and seasonal precipitation, with peak discharge occurring in spring. The formation of ancient river terraces led to the accumulation of alluvial sediments, within which prehistoric sites

such as Butabulak and Chuchukbulak are located. In certain areas, subsurface freshwater layers provided stable sources of drinking and domestic water for ancient communities.

Geological Structure

Geologically, the Karshi oasis consists of Neogene and Quaternary sedimentary rocks, including sand, gravel, clay, limestone, and conglomerate. The Guzar District lies within the piedmont alluvial-fan zone, where ancient river and torrential deposits accumulated over time. Such geological conditions ensured the proximity of raw-material sources essential for prehistoric stone-tool production.

Climate and Soil Conditions

The region is characterized by a dry continental climate, with summer temperatures reaching +38–42 °C and winter temperatures dropping to –5 to –10 °C. Annual precipitation ranges from 250 to 300 mm, falling mainly in spring. Prevailing winds blow from the west and northwest. Soil composition varies: fertile alluvial layers occur along river valleys, while brown and stony-gray soils dominate in the foothill zones. These environmental conditions provided favorable habitats for hunting, gathering, and, later, early agriculture.

Flora and Fauna

The vegetation cover is typical of desert and foothill landscapes. Dominant plant species include *Haloxylon* (saxaul), *Alhagi* (camelthorn), *Astragalus*, *Juniperus*, and *Calligonum*. These plants were likely used as sources of fuel and construction materials in prehistoric times. The fauna includes gazelles, hares, foxes, wolves, wild sheep, and waterfowl such as ducks and geese along river courses—all of which served as major subsistence resources for ancient hunter-gatherer communities.

Landscape Zonation

The Guzar District belongs to the foothill zone, which, from a paleoecological perspective, offered the most favorable conditions for human settlement. The area transitions from the mountain foothills in the north to the Karshi desert plain in the south. The proximity of

water sources, fertile soils, and abundant natural resources contributed to the concentration of prehistoric habitation sites in this zone.

History of Archaeological Research and New Findings

In the Kashkadarya region, the identification and study of Paleolithic and Mesolithic sites began later than in the Surkhandarya region—mainly during the late Soviet period and the years of independence. [Nishiaki, Y., O. Aripdjanov, R. Soleymanov, A. Rajabov, H. Nakata, T. Miki, and S. Arai, 2017] In the 1960s, the Archaeological and Topographical Expedition of Kashkadarya (KATE) of the Institute of Ancient and Medieval Archaeology of the Academy of Sciences of Uzbekistan was established (in 1963). However, the initial focus of this expedition was primarily on sites from the Early Iron Age and historical periods. In the 1980s–1990s, the leadership of KATE changed, and from 1999 onwards, under the direction of Professor R. Kh. Sulaymonov, the Kashkadarya Archaeological Expedition began to pay attention to Stone Age sites as well. As a result, previously unknown Paleolithic sites in the region were discovered.

A new stage began in the early 2000s with the field investigations conducted by R. Kh. Suleymanov, which brought this region back onto the archaeological map of Uzbekistan. His excavations at the Karakamar and Agillak [EPRA Journals. (2020). Archaeological research on the Anghilak and Amir Temur caves of southern Uzbekistan. *International Journal of Multidisciplinary Research*, 7(4), 669–671] sites provided the first reliable evidence of Paleolithic human occupation within the oasis.

Further surveys have since opened a new chapter in the study of the region's prehistoric past. In 2023–2024, the Landscape Archaeology Department of the National Archaeological Center of Uzbekistan, under the direction of PhD A. Muxammadiyev, conducted extensive fieldwork in the Kashkadarya (Guzar) region. The results revealed the great potential of this area for understanding the chronological and cultural sequence of the Stone Age. One of the most important outcomes was the discovery of a new open-air lithic workshop complex—the Butabulak 1–6 sites. [Mukhammadiyev, A., & Landscape Archaeology Department, National

Archaeological Center of Uzbekistan. (2024). *Preliminary results of field research in the Guzar District of Kashkadarya Region* [Unpublished manuscript].

These localities are situated in the Guzar District, within a small intermontane valley between the Katta Uradarya and Langardarya rivers, tributaries of the Guzardarya. The area lies along the northern slopes of the Chakchar Mountains, a southwestern extension of the Hisor Range. Numerous small ravines run north and northwest, where outcrops of Paleogene flint-bearing rocks provided abundant raw materials.

During the 2025 field season, further research led to the discovery of the Chuchukbulak Neolithic settlement, located not far from the Butabulak complex [fig. 1]. This site provides crucial evidence of the cultural and chronological continuity of Stone Age occupation in southern Uzbekistan, bridging the Late Paleolithic and Neolithic periods.

The discoveries made by R. Kh. Suleymanov at the Angillak site, together with the newly identified sites in the Guzar District, contribute to reconstructing the cultural sequence of the Stone Age in the Karshi oasis. Based on lithic typology, Suleymanov tentatively attributed the Angillak assemblage to the Obirahmat cultural tradition. However, the cultural attribution of the discovered Late Paleolithic sites remains open, pending further technological and typological analyses. The current lithic collection is insufficient to allow a definitive cultural classification at this stage.

At the Butabulak 1–6 complex, the technical and typological characteristics of the recovered artifacts, along with the patina covering their surfaces, make it possible to date them from the Late Paleolithic to the Neolithic period. Such features are typically characteristic of stone-working workshops, and the composition of the assemblage as well as the spatial distribution of finds suggest that workshop-settlement type sites may also exist in this area.

At present, these collections are being thoroughly studied, and definitive conclusions about them will be presented in future research. Considering that fieldwork at the Chuchukbulak Neolithic settlement is planned to continue in March–April 2026, it is premature to provide final conclusions regarding the overall collections.

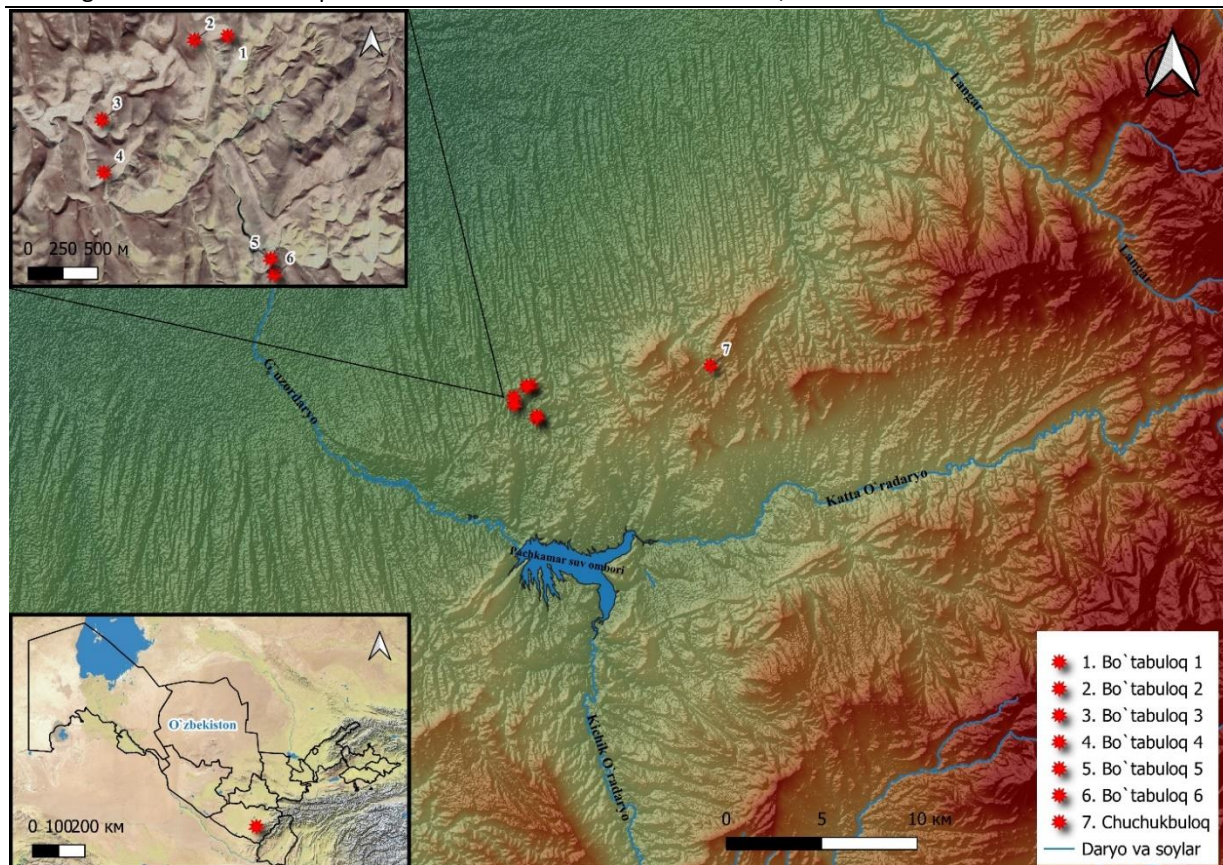


Figure 1. Location of the Butabulak and Chuchukbulak archaeological sites (prepared using QGIS 3.44.4).

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MEDICAL SCIENCES

VITAMIN D AND MALE ERECTILE FUNCTION: AN UPDATED REVIEW

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Abstract

Literature support that vitamin-D is important for different systems of the human body including, but not limited to endocrine and immune systems, vasculature and endothelial function of the body. Male erectile function depends on many factors and can be perceived as a health indicator of the body. Epidemiological data have shown that vitamin-D deficiency is also associated with erectile dysfunction. In this review, our aim is to interpret the mechanisms by which vitamin-D might regulate anatomy and physiology of penis. Evidence showed that vitamin-D is needed for an adequate erectile function. Briefly, vitamin-D is crucial for a better healthy body and sexual activity.

Keywords: Andrology, Endothelium, Erectile dysfunction, Hormones, Male, Vascular endothelium

Introduction

Human sexual activity is the manner in which humans experience and express their sexuality. Male penile erection is a physiological phenomenon in which the penis becomes firm, engorged, and enlarged in response to sexual arousal during sexual activity (1). Penile erection is the result of a complex interaction of psychological, neural, vascular, and endocrine factors in the presence of a normal penis anatomy (2). Penile erection is initiated by nitric oxide (NO), a potent vasodilator, released from the nerve endings, further production of NO depends on increased blood flow which is also known as shear stress (3). In most vascular beds, the NO is released by a stimulus that increases the shear stress over the endothelium. Endothelial dysfunction is a key variable in the pathogenesis of atherosclerosis and its complications, including erectile dysfunction (ED).

ED is defined as the inability to attain or maintain erection sufficient for satisfactory sexual activity (2). Over the past 20 years, there have been numerous reports on the epidemiology of ED all over the world (4-7). In all studies, it was demonstrated that the prevalence of ED increases with age (4, 7). In other words, higher age is strongly associated with higher incidence of ED (7, 8). In men under the aged 40 to 49 years, the prevalence of ED was relatively low (~40%) and in men aged 70 to 79 years, the prevalence of ED was significantly higher (~90%) (6, 7, 9). The etiology of ED has been studied comprehensively and found to be multifactorial. ED is frequently found in vascular syndromes, such as atherosclerotic cardiovascular (ASCV) diseases, hypertension, cerebrovascular disease, peripheral arterial disease and diabetes mellitus (DM) (8, 10,

11, 12). In fact, the penis is a highly vascularized organ and erections are primarily vascular events. Both ED and ASCV diseases have frequently identical functional and morphologic basis (3, 12). Because of its vascularity, ED is even accepted as a marker of coronary endothelial dysfunction and atherosclerosis (10, 12).

In the last decades, several studies have correlated ED risk factors with vitamin-D (VD) deficiency (VDD) (5, 13, 14). Observational and interventional studies published in literature have established a strong relationship between VD levels and ED. This important knowledge turned scientists to go in deep for the effect of VD on erectile function. Shortly, it is now well known that VD is a part of well-functioning penis starting from the early days of our lives.

Vitamin D

VD, which is actually a steroid hormone, has much more assorted role in human body for a vitamin than previously recognized just for calcium metabolism (15). Since it was shown that VD-receptor (VDR) is expressed in all tissues of human body including penis, VD regulates cellular differentiation and function across many cell types (1, 16-23). VD effects are facilitated through binding to the VDR and stimulating not only genomic but also non-genomic effects (19[^] 22). Upon VD binding, VDR translocates from the plasma membrane to the nucleus where it transcriptionally activates genes *via* the VD response element, thereby affecting transcription of other genes (19). Human Genome Project study results showed that a human DNA has between 20,000 and 25,000 genes (24), and more important to us, surprisingly, over 3,000 genes are responsive to VD (25).

Unfortunately, the estimated worldwide prevalence of VDD is really high and common among the elderly. VDD is about 50% at older ages and this result underlines the importance of VDD for public health (26, 27). If we consider that VD effect many tissues, VDD becomes more and more important for a healthy sexual life, in other words for erectile function.

1. Essentials of vitamin-D

Vitamins D2 (ergocalciferol) and D3 (cholecalciferol) are two dominant forms of VD. Vitamin D2 is synthesized by invertebrates and plants after exposure to ultraviolet radiation (1). Vitamin D3 is naturally present in a small range of foods (such as oily fish, egg and fortified dairy products) and is also made endogenously in the skin. Dietary VD typically comprises only 10% to 20% of circulating levels of VD (28). If we look at the VD physiology, one can see that Vitamin D2 and D3 are biologically inactive and subjected to double hydroxylation, first mainly in the liver and then in the kidney, to produce the biologically active compound calcitriol (1, 14, 21, 29, 30). Although 1,25(OH)₂D is the most active form of VD and undertakes the major biological function, it has a shorter half-life (~0.3 and 25 days, respectively) and a 1,000-fold lower concentration than 25(OH)D (31). More importantly, serum 25(OH)D is relatively stable and not directly influenced by diet (*e.g.*, calcium intake) and life style (*e.g.*, mobility) (31). Hence, total-body VD stores are best reflected by 25(OH)D (31). Earlier, it was proved that availability of ultraviolet-B exposure, and its resultant VD production in skin, is highest in late spring through early fall and lowest from late fall through early spring (26). In addition to seasonal variations, there are many other factors that can affect the prevalence of VDD. These can be summarized as region and latitude, diet and supplement use, clothing, obesity, smoking, concerns about sun damage, and the nature of built environment (32).

Vitamin D and erectile dysfunction

A general population study showed that low serum VD was associated with higher prevalence of peripheral arterial disease (33). Likewise, a very recent cross-sectional analyses (3,390 men aged >20 years, free of ASCV disease) also reported that VDD was associated with an increased ED prevalence (14). In support, deficient levels of VD <20 ng/mL were associated with increased ED risk, where a decreased prevalence of ED was associated with VD levels >35 ng/mL (14). When researchers restricted their analysis to the 562 men (among 3,390 men) adjusted for sex hormone levels, the association of VD with ED became even stronger (14). The biological link between VDD and ED exhibits several interlaced mechanisms that could suggest that the link of VD with ED appears to be independent of sex hormones (14).

1. Vitamin-D and architecture of the penis

There are many risk factors in the etiology of ED which might be directly arising from VDD. Since the latest literature showed the importance of VD on erectile function, Fernandes-Lima et al (34) investigated the effects of VD restricted diet on Wistar rats offspring penis morphology. Fernandes-Lima et al (34) demon-

strated that VD restriction during perinatal and postnatal periods induced metabolic and structural changes and represented important risk factors for ED in the penis of the adult offspring. The latter findings suggest that VD is an important micronutrient in maintaining the cytoarchitecture of the penis (34). In other words, human body requires VD for the proper anatomical development of the penis during embryonal life.

2. Vitamin-D and endothelial function

The pathophysiology of ED is multifactorial, but common point is a vascular disorder related to decreased endothelial function. Indeed, one of the most significant mechanism of VD on erectile function seems to work *via* endothelial integrity (30, 35). In molecular levels, VD stabilizes the quiescent endothelium, regulates certain stages of endothelial activation, and is involved in the repair of the damaged endothelium *in vitro* and *in vivo* models. A recent 12 cross-sectional studies, including 2,086 subjects of varying ethnic groups, showed an association between endothelial dysfunction and VDD (36). Also, VD may directly protect endothelial cells against oxidative stress, and hence, VDD may contribute to ED through inflammation (30).

Many ED patients are VD deficient, particularly patients with arteriogenic ED (5). Epidemiological data in humans have shown that VDD is associated with hypertension, left ventricular hypertrophy, increased arterial stiffness, and endothelial dysfunction in normal subjects (30). Men with ED have an increased prevalence of endothelial dysfunction, and VD may improve endothelial function (14). A placebo-controlled randomized trial demonstrated that even a single large dose of VD improves endothelial function in patients with type 2 diabetes and VDD (37). Since endothelial function improvement is the cornerstone of the treatment of ED, VD supplementation may be beneficial in the treatment of ED patients.

3. Vitamin-D and nitric oxide production

Another important mechanism of action of VD seems to be *via* NO mediated vascular dilation. NO synthases (NOS) are a family of enzymes that catalyze the production of NO from L-arginine. NO-pathway is a well-known physiologic signal essential to penile erection. Shortly, sexual stimulation releases neurotransmitters from the corpus cavernosa as well as NO (a relaxing factor) from the endothelial cells of the penis (28). Any kind of disorders that reduce NO synthesis or release in the erectile tissue are commonly associated with ED. Activated VD stimulates the production of NO in endothelial cells and NOS (38), and is a key to vascular dilation and thereby critical to preventing ED. Molinari et al (38) demonstrated that VD is able to stimulate NO production in human umbilical vein endothelial cells through endothelial NOS (eNOS) activation.

The finding of an involvement of VD in NO production by endothelial cells is quite relevant. Recently, Andrukhova et al (30) reported that VDR mutant mice are characterized by lower bioavailability of the vasodilator NO due to reduced expression of the key NO synthesizing enzyme *i.e.*, eNOS. Reduction in eNOS ends with endothelial dysfunction, increased arterial

stiffness, increased aortic impedance, structural remodeling of the aorta, and impaired systolic and diastolic heart function at later ages, independent of changes in the renin-angiotensin system (30). This may also clarify why endothelium derived; NO-evoked dilation is halved in arteries from VD deficient male rats (35). Under the light of recent scientific researches, unsurprisingly, there exists a higher prevalence of ED among VD deficient patients compared to those with optimal levels (14).

4. Vitamin-D and atherosclerotic cardiovascular diseases

Penile erection predominantly depends on vascular event and according to several studies there is a strong association between ED and ASCV diseases (39). Unfortunately, VDD is associated with atherogenic dyslipidemia, DM, and reduced serum testosterone (T) levels all of which are associated with endothelial dysfunction and are classic risk factors for the onset of ED (13, 14, 18).

Recently, Barassi et al (5) demonstrated a higher presence of VDD in arterial ED patients compared with non-arterial-ED patients and a lower serum VD levels in more severe ED patients. Melamed et al (33) has shown that low serum VD levels are associated with a higher prevalence of peripheral arterial disease in the general population. Additionally, an earlier study done with more than 7,000 VD deficient patients showed an association between VDD and several cardiovascular disease (CVD) states such as hypertension, coronary artery disease as well as ASCV risk factors (DM, dyslipidemia etc.) (18). However, a recent cross-sectional analysis of 3,390 men aged >20 years, found that VDD in individuals free of ASCV diseases was associated with an increased prevalence of ED (14).

The available literature evaluating VD supplementation and its relationship to ASCV diseases are limited in number. However, in an observational retrospective study involving more than 10,000 patients Vacek et al (18) showed that VD supplement use improved survival in deficient subjects, supporting the potential benefit of this intervention. Later, in a randomized placebo-controlled preliminary study, Al-Dujaili et al (40) suggested that daily VD supplementation may ameliorate CVD risk factors.

5. Vitamin-D and endocrine system

T modulates nearly every component involved in erectile function and its deficiency associated with ED (41). In an ageing male population, hypogonadism is common (30% prevalence in men >60 years), and is associated with ASCV risks (e.g., atherogenic lipid profile, insulin resistance and obesity) (42). The Longitudinal Aging Study Amsterdam, showed serum VD was positively associated with total and bioavailable T levels (43). In another study, with large population group (2,854 men), investigators revealed that a lower VD level is associated with a higher prevalence of hypogonadism (44). The latter result was supported by another study of 652 men over 40 years of age (45). VD was significantly and positively associated with T levels before and after adjustment for age and ethnicity (46).

VD is positively associated with T, exhibits a concordant seasonal changeability (47), elevates when T was supplemented in hypogonadism (48). Surprisingly, the reverse situation is also true, suggesting that VD supplementation might increase T levels (49). In a clinical randomized controlled trial, which is the first on this topic in literature, Pilz et al (49) investigated the effect of VD supplementation on androgens in men. The results were significant and the researchers observed that overweight men with VDD had a clinically meaningful increase in serum T levels after VD supplementation for 1 year (49). Recently, it was also demonstrated that VD supplementation improves T levels, metabolic syndrome and erectile function in middle-aged VD deficient men (8). Canguven et al (8) supported earlier research where serum total-T effectively increased after VD treatment (49-50). Likewise, Wehr et al (47) demonstrated that androgen levels were associated with VD levels in 2,299 older men; and also a cross-sectional analysis of men in a national survey found that increasing VD ends with higher total-T levels (51). Certainly, it has been advocated that the most advantageous serum VD concentrations begin at 30 ng/mL, and the best are between 36 to 40 ng/mL (52).

6. Vitamin-D and androgen receptors

An extra mechanism of VD on erectile function seems to function *via* binding to T receptors. Computer (*in silico*) modeling shows that besides activating the VDR, 1,25-D displays high affinity for some of the body's other nuclear receptors. This suggests that when 1,25-D increases above its normal range, it binds the α/β thyroid, the glucocorticoid, and the T receptors, displacing their native ligands (53). Marshall (54) showed the symmetry with which endogenous ligands exhibited very similar affinities across some members of the type 1 nuclear receptor family (54). For example, 1,25-D docked into the VDR with a (nanomolar) Kd of 8.48, but also exhibited a Kd of 8.05 into the T receptor.

7. Vitamin-D and immune system

ED is associated with an incremental inflammatory activation and inflammation plays an important pathophysiological role in both ED and ASCV diseases (12, 39, 55). It has been extensively debated that inflammation can exert a detrimental effect on the ASCV system *via* two pathways: chronic, low-grade inflammation and an acute systemic inflammatory response. The former has been implicated in atherosclerotic processes (56), while the latter accounts for adverse ASCV events following severe inflammatory stimulation. Sildenafil, one of the phosphodiesterase inhibitors used as first line treatment in ED, induces a significant acute decrease in levels of pro-inflammatory markers/mediators (55). The anti-inflammatory action might play an important role in addition to relaxation of penile smooth muscles.

Ding et al (50) revealed that VD supplement may protect the cells through suppressing inflammation factors and alleviating cell apoptotic death, as well to reproduction and T synthesis. Ding et al' study (50) indicated that VD played a protective role of testes and testicular damage induced by diabetes, and the possible mechanism might be regulating attenuating inflammation and inactivating caspase cascade. Emerging data

suggests that VD has a potential role in regulating inflammation. In research, it was shown that VD inhibits the expression of inflammatory cytokines in monocytes, including interleukins-1, 6, 8, 12, and tumor necrosis factor- α (57, 58). In summary, VD may directly defend endothelial cells against oxidative stress; and VDD may contribute to ED through inflammation.

Conclusions

Based on the evidence from bench and bed, it was shown that VD is important for erectile function. Measurement of VD in ED patients is very crucial with supplementation as required. VD supplementation potentially represents a low-cost, low-risk method to treat and prevent ED. In summary, we need VD starting from the early embryonal days to the end of our lives for a better, healthy and sexually active life.

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VITAMIN D AND THE SKIN: FOCUS ON A COMPLEX RELATIONSHIP: A REVIEW

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The "sunshine" vitamin is a hot topic that attracted ample attention over the past decades, specially that a considerable proportion of the worldwide population are deficient in this essential nutrient. Vitamin D was primarily acknowledged for its importance in bone formation, however; increasing evidence point to its interference with the proper function of nearly every tissue in our bodies including brain, heart, muscles, immune system and skin. Thereby its deficiency has been incriminated in a long panel of diseases including cancers, autoimmune diseases, cardiovascular and neurological disorders. Its involvement in the pathogenesis of different dermatological diseases is no exception and has been the subject of much research over the recent years. In the current review, we will throw light on this highly disputed vitamin that is creating a significant concern from a dermatological perspective. Furthermore, the consequences of its deficiency on the skin will be in focus.

Keywords: Vitamin D, Deficiency, Dermatology, Immunological

Introduction

It is somewhat ironic that vitamin D, through a historical accident, became classified as a 'vitamin', owing to the fact that vitamin is conventionally defined as 'essential item needed in the diet'. The paradox with 'vitamin D' is that diet per se is usually poor in vitamin D except for cod or other fish oils or food fortified with this vitamin [1].

Vitamin D is actually a fat-soluble prohormone steroid that has endocrine, paracrine and autocrine functions [2]. The endocrine effects of vitamin D are mainly involved in serum calcium homeostasis. Vitamin D and calcium are often used in the same sentence because they work closely together, vitamin D's primary role is to control the levels of calcium found in the bloodstream by constantly allowing calcium and phosphate absorption from the intestine or taking calcium from bones. Furthermore, vitamin D is an enabling agent that, when present in optimal concentrations, has no perceptible effect on calcium absorption in its own right; however, it permits or facilitates flexible physiologic response to varying calcium need [3].

The paracrine and autocrine effects of vitamin D depend on genetic transcription, unique to the type of cell expressing nuclear vitamin D receptors. These potential effects include inhibition of cell proliferation, promotion of cell differentiation, and apoptosis which may in turn have roles in cancer, immunity, and many organ systems (4-8). The potential myriad effects of this vitamin in human health and disease have led to an escalating interest in vitamin D inadequacy and the best methods to normalize suboptimal levels.

Sunlight

The most well-known source of vitamin D is via synthesis in the skin induced by sun exposure. The first reference to the physiological effect of sunlight on vitamin D was illustrated by the Greek historian Herodotus. He visited the battlefield where Cambyses (525 BC) overcame the Egyptians, and inspected the skulls of slain Persians and Egyptians. He noted that the Persian skulls were so fragile that they broke even when struck with a pebble, whereas those of the Egyptians were strong and could scarcely be broken even when struck with a stone. The Egyptians' explanation to Herodotus was that they went bareheaded from childhood exposing their heads to sunlight, whereas Persians covered their heads with turbans shading them from the sun resulting in skull bone weakness. Later on, in the mid 17th century Francis Glisson, Professor of Physics at Cambridge University, in his treatise on rickets observed that the disease was common among infants and young children of country farmers who ate well, and whose diets were known to include eggs and butter, but who lived in rainy, misty parts of the country and who were kept indoors during long severe winters (11).

Vitamin D synthesis in the skin

According to the Commission Internationale de l'Eclairage (CIE) (12), the vitamin D effective radiation is described in terms of its action spectrum (i.e., the efficiency of each wavelength to synthesize vitamin D in skin) which covers the spectral range (255–330 nm) with a maximum at about 295 nm (UVB). A whole body exposure to UVB radiation inducing the light pink color of the minimal erythema dose for 15–20 min is able to induce the production of up to 250 µg vitamin D (10,000 IU) [13], [14].

Its precursor 7-dehydrocholesterol in the plasma membranes of both epidermal basal and suprabasal keratinocytes and dermal fibroblasts is converted to previtamin D₃. Cutaneously synthesized vitamin D₃ is released from the plasma membrane and enters the systemic circulation bound to vitamin D-binding protein (DBP) (15). Serum concentrations of vitamin D₃ peak 24–48 h following exposure to UV radiation (13). Thereafter, vitamin D₃ levels decline exponentially with a serum half-life ranging from 36 to 78 h (13,14). As a lipid-soluble molecule, vitamin D₃ can be taken up by adipocytes and stored in subcutaneous or omental fat for later use (16). The distribution of vitamin D₃ into adipose tissue prolongs its total-body half-life to approximately two months as first detected on experiments on submarine personnel (17-19).

Once in the circulation, vitamin D is converted by a hepatic hydroxylase into 25-hydroxyvitamin D (25(OH)D; calcidiol). The circulating 25(OH)D level is an indicator of the vitamin D status. This level reflects both ultraviolet exposure and dietary vitamin D intake. The serum half-life of 25(OH)D is approximately 15 days (2). 25(OH)D is not biologically active except at very high, non-physiological levels (20). As needed, 25(OH)D is converted in the kidney to its active hormonal form 1,25-dihydroxyvitamin D (1,25(OH)₂D; calcitriol) in a process which is usually tightly controlled by the parathyroid hormone which levels start rising at 25(OH)D cutoff levels of 75 nmol/L or lower. In spite of this, inadequate vitamin D supply lowers the circulating level of calcitriol (16). Circulating calcitriol is also adversely affected by a reduced number of viable nephrons, high serum concentrations of fibroblast growth factor-23, and high levels of inflammatory cytokines such as interleukin (IL)-1, IL-6, and tumor necrosis factor- α (TNF- α) (19, 21).

It is important to know that the conversion of previtamin D₃ to the inactive photoproduct lumisterol and tachysterol balances the cutaneous biosynthesis of vitamin D₃ as a feedback loop. This mechanism ensures that one cannot “overdose” on vitamin D₃ by photoexposure alone. After less than 1 minimal erythema dose (MED; i.e., the amount of photoexposure required to produce faint pinkness in the skin at 24 h after exposure), the concentration of previtamin D₃ reaches maximal levels and further UV radiation merely results in the production of inactive metabolites (2).

Dietary sources and supplements

Vitamin D is available in 2 distinct forms, ergocalciferol (vitamin D₂) and cholecalciferol (vitamin D₃). Sunshine exposure provides vitamin D in the form of D₃ only, while dietary sources are able to provide both forms, which are officially regarded by many as equivalent and interchangeable (22-24). However, several reasons have been suggested to argue against this presumption including that both are different in their efficacy at raising serum 25-hydroxyvitamin D, with diminished binding of vitamin D₂ metabolites to vitamin D binding protein in plasma, as well as the detection of a nonphysiologic metabolism and shorter shelf life for vitamin D₂. Nevertheless, still to this day, the major preparations of vitamin D for prescription are in the

form of vitamin D₂, not vitamin D₃. Multivitamins may contain either vitamin D₂ or vitamin D₃, but most companies are now reformulating their products to contain vitamin D in the D₃ form (25).

There are only few natural sources of vitamin D including cod liver oil, cheese, egg yolks, mackerel, salmon, tuna fish, and beef liver. Because it is not easy for many individuals to obtain adequate vitamin D intake from natural dietary sources alone, many countries fortify foods such as orange juice, milk, yogurt, and cereal with vitamin D. Many inexpensive supplemental vitamin D forms are readily available over the counter in both vitamin D₃ and vitamin D₂ forms and with or without calcium (26, 27).

Vitamin D levels

Different cut-off values for the normal threshold of vitamin D have been used until recently (28). A level of 50 nmol/L has been widely used to define 25(OH)D insufficiency, while some studies have used 37.5 nmol/L as the lowest level of sufficiency (29-31). Further studies, however, suggest that a 25-(OH)D level as high as 75 nmol/L or higher is needed to cover all physiological functions of vitamin D and should therefore be considered optimal (32-36).

Factors influencing vitamin D level

Nutrient deficiencies are usually the result of dietary inadequacy, impaired absorption and use, increased requirement, or increased excretion. Vitamin D deficiency can occur when usual intake is lower than recommended levels over time, exposure to sunlight is limited, the kidneys cannot convert 25(OH)D to its active form, or absorption of vitamin D from the digestive tract is inadequate. Vitamin D-deficient diets are associated with milk allergy, lactose intolerance, ovo-vegetarianism, and veganism (37).

Regarding the amount of vitamin D production in human skin, it depends on several variables including environmental factors such as geographic *latitude*, *season*, *time of day*, *weather conditions* (cloudiness), amount of *air pollution* and *surface reflection* which can all interfere with the amount of UVB radiation reaching the skin (38-41).

Personal variations represent another group of influential factors affecting the vitamin D production in the skin, including *age* as elderly people have thinner skin, and consequently are less capable of synthesizing vitamin D (7, 38, 39) and *obesity* as overweight individuals have reduced vitamin D levels (42). It is also noteworthy that *skin type* determines a person's effectiveness in producing vitamin D. Light skins (type I) produce up to six fold the amount of vitamin D produced by dark skins (type VI). In addition, *clothing habits*, *lifestyle*, *workplace* (e.g., indoor versus outdoor), and *sun avoidance practices* have a strong impact on vitamin D synthesis (38-41).

The influence of some common practices as using *sunblocks* or receiving *sunbeds* on vitamin D production is another point of interest. Sunblocks are known to block UVB radiation effectively. However, it is questionable whether sunscreen in practice causes any vitamin D deficiency. Absolute full-body coverage of sunscreen is uncommon. Some areas of the skin are always left out. At times and locations where the sun is

intense and the temperature is high enough to make the population use sunscreen, its vitamin D status is generally very satisfactory (39-41). On the other hand the use of sun beds is controversial, but regardless, subjects who regularly use tanning beds that emit UVB radiation are likely to have higher 25(OH)D concentrations. Nevertheless, there is a trend toward discouraging the use of such tanning beds for fear of melanoma and non-melanoma skin cancer (43).

Vitamin D: What's beyond its synthesis and metabolism?

The skin is unique in being not only the source of vitamin D for the body but also in being capable of responding to the active metabolite of vitamin D, 1,25(OH)2D. Both 1,25(OH)2D and its receptor (VDR) play essential roles in the skin.

Skin differentiation and proliferation

Both calcium and 1,25(OH)2D perform important and interacting functions in regulating the skin differentiation process. 1,25(OH)2D increases the expression of involucrin, transglutaminase, loricrin, and filaggrin and increases keratinocyte cornified envelope formation while inhibiting proliferation (44, 45). These actions are due to, at least in part, the ability of 1,25(OH)2D to increase intracellular calcium levels achieved by induction of the calcium receptor (46), and the phospholipase C (47) that are critical for the ability of calcium to stimulate keratinocyte differentiation (48, 49). Mice lacking the VDR show defective epidermal differentiation manifesting as reduced levels of involucrin and loricrin and loss of keratohyaline granules (50, 51).

Cutaneous antimicrobial effects

1,25(OH)2D and its receptor regulate the processing of the long chain glycosylceramides that are critical for the skin barrier formation (52) which is crucial in defending the skin. Furthermore, they induce toll like receptor 2 (TLR2) and its coreceptor CD14, that initiate the innate immune response in skin (53). Activation of these receptors leads to the induction of CYP27B1, which in turn induces cathelicidin resulting in the killing of invasive organisms (53, 54). Mice lacking the VDR or the enzyme (CYP27B1) show decreased lipid content of the lamellar bodies leading to a defective permeability barrier (52), and a defective response of the innate immune system to invading infections (53).

Vitamin D and cutaneous innate immunity

The historical link between vitamin D and innate immune function stemmed initially from the use of cod liver oil as treatment for tuberculosis (TB) (54). More recent work has focused on the cellular and molecular machinery that underpins the actions of vitamin D on the pathogen that causes TB, *Mycobacterium tuberculosis* (M. TB). In the first of these studies, carried out 25 years ago, active 1,25(OH)2D was shown to reduce the proliferation of M. TB in macrophages with this effect being enhanced by the cytokine interferon γ (IFN γ), a known stimulator of macrophages (55). However, the major advance in our understanding of how vitamin D directs antibacterial responses in TB arose from much more recent studies aiming at defining the way by which monocytes and macrophages, key cells

in directing bacterial killing, respond to an encounter with M. TB (56). These data suggested that monocytes promote localized activation of vitamin D in response to M. TB, with the resulting 1,25(OH)2D binding to endogenous VDR. In this way, vitamin D can act to modulate gene expression in response to M. TB immune challenge – a classical intracrine mechanism (57, 58). Functional analyses showed that 25OHD-mediated induction of cathelicidin is coincident with enhanced killing of M. TB in monocytes. Naturally occurring variations in serum 25OHD have been shown to correlate with induction of monocyte cathelicidin expression (59). The conclusion from these studies was that individuals with low serum 25OHD will be less able to support monocyte induction of antibacterial activity and may therefore be at greater risk of infection. Conversely, supplementation of vitamin D-insufficient individuals *in vivo* has been shown to improve TLR-mediated induction of monocyte cathelicidin (60) and may therefore help to protect against infection.

Studies have shown that T-cell cytokines play a pivotal role in both amplifying and attenuating vitamin D-mediated cathelicidin production (61). Indeed, cytokine production by monocytes themselves may be central to the intracrine metabolism of vitamin D in this cell type (62, 63). Thus, it seems likely that the ability to mount an appropriate response to infection will be highly dependent on the availability of vitamin D, with additional tuning of this response by other components of the normal human immune response.

Vitamin D can also influence innate immune responses to pathogens via effects on antigen presentation by macrophages or dendritic cells. These cells are known to express VDR (64), and treatment with 1,25(OH)2D has been shown to inhibit DC maturation, suppress antigen presentation and promote a tolerogenic T-cell response (65, 66).

Vitamin D and cutaneous adaptive immunity

Early studies of vitamin D and the immune system demonstrated VDR expression in both T and B cells (67). Notably, VDR expression by these cells was only immunologically functional in active, proliferating cells, suggesting an antiproliferative role for 1,25(OH)2D on these cells (68). T helper (Th) cells appear to be the principal target for 1,25(OH)2D which can suppress Th cell proliferation as well as modulating cytokines production by these cells (69). Activation of naive Th cells by antigen in turn leads to the generation of Th cell subgroups with distinct cytokine profiles: Th1 (IL-2, IFN γ , tumor necrosis factor alpha) and Th2 (IL-3, IL-4, IL-5, IL-10) that respectively support cell-mediated and humoral immunity (70-71).

In vitro 1,25(OH)2D inhibits Th1 cytokines (72), while promoting Th2 cytokines (73). A third group of Th cells known to be influenced by vitamin D are interleukin-17 (IL-17)-secreting T cells (Th17 cells). Auto-immune disease-susceptible non obese diabetic (NOD) mice treated with 1,25D exhibit lower levels of IL-17 (74), and 1,25(OH)2D-mediated suppression of murine retinal autoimmunity appears to involve inhibition of Th17 activity (75). Furthermore, subsequent studies

have shown that 1,25(OH)₂D suppresses IL-17 production via direct transcriptional suppression of IL-17 gene expression (76).

Another group of T cells known to be potentially induced by 1,25(OH)₂D are regulatory T cells (Tregs) (77). Although part of the Th cell family, Tregs act to suppress immune responses by other T cells as part of the machinery to prevent over-exuberant or autoimmune responses (78). Recent studies have underlined the importance of Tregs in mediating the immunoregulatory actions of vitamin D. Administration of 1,25(OH)₂D systemically to patients who underwent renal transplantation has been shown to expand circulating Treg populations (79).

Studies of vitamin D and T-cell function have to date focused primarily on the response of these cells to active 1,25(OH)₂D. What is less clear is the mechanism by which variations in vitamin D status can also influence T cells, despite reports linking serum levels of 25OHD with specific T-cell populations (56). For example, circulating levels of 25OHD have been shown to correlate with Tregs activity in patients with multiple sclerosis (80, 81). There are four potential mechanisms by which serum 25OHD is believed to influence T-cell function; (i) direct effects on T cells mediated via systemic 1,25(OH)₂D; (ii) indirect effects on antigen presentation to T cells mediated via localized DC expression of CYP27B1 and intracrine synthesis of 1,25(OH)₂D; (iii) direct effects of 1,25(OH)₂D on T cells following synthesis of the active form of vitamin D by CYP27B1-expressing monocytes or DCs – a paracrine mechanism; (iv) Intracrine conversion of 25OHD to 1,25(OH)₂D by T cells. As yet, it is unclear whether one or more of these mechanisms will apply to the regulation of specific T-cell types. For example, the effects of 1,25(OH)₂D on Tregs can occur indirectly via effects on DCs (82), but may also involve direct effects on the Tregs (83). However, as DCs also express CYP27B1 (84) and may therefore act as the conduit for 25OHD effects on Tregs. Interestingly, reports have also described expression of CYP27B1 by T cells (85), suggesting that 25OHD may also influence the function of these cells via an intracrine mechanism, although the precise relevance of this to specific T-cell types remains unclear (56).

Despite the fact that expression of VDR by B cells has been recognized for many years (67), the ability of 1,25(OH)₂D to suppress B-cell proliferation and immunoglobulin (Ig) production was initially considered to be an indirect effect mediated via Th cells (68). However, more recent studies have confirmed direct effects of 1,25(OH)₂D on B-cell homeostasis (86), with notable effects including inhibition of plasma cells and class switched memory cells differentiation. These effects lend further support for vitamin D's proposed role in B-cell-related autoimmune disorders such as systemic lupus erythematosus. Other B-cell targets known to be modulated by 1,25(OH)₂D include IL-10 (87) and CCR10 (88), suggesting that the repertoire of B-cell responses to vitamin D extends beyond its effects on B-cell proliferation and Ig synthesis (56).

Hair follicle cycling

In vitro studies have supported the concept that VDR may play a vital role in the postnatal maintenance of the hair follicle. Mesodermal papilla cells and the outer root sheath (ORS) epidermal keratinocytes express VDR in varied degrees in correlation with the stages of the hair cycle. In both the late anagen and catagen stages there is an increase in VDR, which is associated with decreased proliferation and increased differentiation of the keratinocytes. These changes are thought to promote the progression of the hair cycle (89).

Limited studies have been done in humans to elaborate the role of vitamin D in the hair cycle. A potential application for vitamin D is in chemotherapy-induced alopecia. Topical calcitriol has been shown to protect against chemotherapy-induced alopecia caused by paclitaxel and cyclophosphamide. However, topical calcitriol failed to protect against chemotherapy-induced alopecia caused by a combination of 5-fluorouracil, doxorubicin, and cyclophosphamide and a combination of cyclophosphamide, methotrexate, and 5-fluorouracil. The ability of topical calcitriol to prevent chemotherapy-induced alopecia may therefore depend on the chemotherapy agents used. Of note, the studies in which no effects were observed, were small and may have used doses of vitamin D that were inadequate to protect against chemotherapy-induced alopecia (90).

The sebaceous gland

It has been reported that incubation of the human sebaceous gland cell line with 1,25(OH)₂D results in a dose-dependent suppression of cell proliferation. Using real-time PCR, it was demonstrated that key components of the vitamin D system (VDR, 25OHDase, 1 α O-Hase, and 24OHDase) are strongly expressed in such cells. It has been concluded that local synthesis or metabolism of vitamin D metabolites may be of importance for growth regulation and various other cellular functions in sebaceous glands and that sebaceous glands represent promising targets for therapy with vitamin D analogs or for pharmacological modulation of calcitriol synthesis/metabolism (91, 92).

Photoprotection

Photodamage refers to skin damage induced by ultraviolet (UV) light. Depending on the dose, UV light can lead to DNA damage, inflammatory responses, skin cell apoptosis (programmed cell death), skin aging, and skin cancer. Some studies, mainly *in vitro* (cell culture) studies (93-96) and mouse studies where 1,25-dihydroxyvitamin D₃ was topically applied to skin before or immediately following irradiation (93, 97, 98), have found that vitamin D exhibits photoprotective effects. Documented effects on skin cells include decreased DNA damage, reduced apoptosis, increased cell survival, and decreased erythema. The mechanisms for such effects are not known, but one mouse study found that 1,25-dihydroxyvitamin D₃ induced expression of metallothionein (a protein that protects against free radicals and oxidative damage) in the stratum basale (93). It has also been postulated that non-genomic actions of vitamin D contribute to the photoprotection (99); such effects of vitamin D involve cell-signaling cascades that open calcium channels (100).

Wound healing

1,25-Dihydroxyvitamin D₃ regulates the expression of cathelicidin (LL-37/hCAP18) (53, 57), an antimicrobial protein that appears to mediate innate immunity in skin by promoting wound healing and tissue repair. One human study found that cathelicidin expression is upregulated during early stages of normal wound healing (58). Other studies have shown that cathelicidin modulates inflammation in skin (101), induces angiogenesis (102), and improves reepithelialization (the process of restoring the epidermal barrier to re-establish a functional barrier that protects underlying cells from environmental exposures) (103). The active form of vitamin D and its analogs have been shown to upregulate cathelicidin expression in cultured keratinocytes (58, 104). However, more research is needed to determine the role of vitamin D in wound healing and epidermal barrier function, and whether oral vitamin D supplementation or topical treatment with vitamin D analogs is helpful in healing surgical wounds.

Vitamin D and skin diseases

Based on the afore mentioned facts concerning the intertwined bonding that exists between vitamin D and skin, it seems only “natural” to incriminate vitamin D deficiency in a long list of cutaneous disorders including skin cancer, psoriasis, ichthyosis, autoimmune skin disorders such as vitiligo, blistering disorders, scleroderma and systemic lupus erythematosus, as well as atopic dermatitis, acne, hair loss, infections and photodermatoses. Nevertheless, it remains speculative whether vitamin D deficiency primarily contributes to disease pathogenesis or merely represents a consequential event to the inflammatory processes involved. According to a recent systematic review including 290 prospective cohort studies and 172 randomized trials of major health outcomes and of physiological parameters related to disease risk or inflammatory status, one solid fact is emphasized; vitamin D deficiency appears to be a marker of ill health (105) regardless of being an actual cause or an association. In the current review we will highlight the most commonly studied dermatological diseases.

Skin cancer

A number of epidemiologic studies have suggested that vitamin D may have a protective effect decreasing cancer risk and cancer-associated mortality (106-110). Adequate vitamin D status has been linked to decreased risks of developing specific cancers, including cancers of the esophagus, stomach, colon, rectum, gallbladder, pancreas, lung, breast, uterus, ovary, prostate, urinary bladder, kidney, skin, thyroid, and hematopoietic system (e.g., Hodgkin's lymphoma, non-Hodgkin's lymphoma, multiple myeloma) (110). With regards to skin cancer, epidemiologic and laboratory studies have reported mixed findings, with some reporting an association between higher vitamin D levels and increased skin cancer risk (111), others showing a decreased skin cancer risk (106-109), and still others showing no association (106). The key findings that point to the role of vitamin D in the prevention of the initiation and progression of lethal skin cancers are the involvement of vitamin D in regulation of multiple sig-

naling pathways that have implications in carcinogenesis (109), among which are the inhibition of the hedgehog signaling pathway, the pathway underlying development of basal cell carcinomas, and upregulation of nucleotide excision repair enzymes (106). Furthermore, vitamin D induces cellular arrest, triggers apoptotic pathways, inhibits angiogenesis, and alters cellular adhesion (108). Another point is that skin cancer metastasis depends on the tumor microenvironment, where vitamin D metabolites play a key role in prevention of certain molecular events involved in tumor progression (109). The key factor complicating the association between vitamin D and skin cancer is ultraviolet B radiation. The same spectrum of ultraviolet B radiation that catalyzes the production of vitamin D in the skin also causes DNA damage that can lead to epidermal malignancies. Overall, there is some evidence that vitamin D may play a role in nonmelanoma skin cancer (NMSC) including basal cell and squamous cell carcinoma as well as melanoma prevention, although as of yet there is no direct evidence to show a protective effect (106).

Psoriasis

Psoriasis is a chronic inflammatory skin disease that affects 2–3% of the population worldwide and causes significant morbidity (112). Although the pathogenesis of psoriasis is not fully understood, there is ample evidence suggesting that the dysregulation of the immune cells in the skin, particularly T cells, plays a critical role in psoriasis development (113).

Several studies have focused on the possible role of vitamin D deficiency in psoriasis (114-116). The exact mechanism by which vitamin D deficiency contributes in such a complex pathogenesis is not fully understood. Several pathways have been established including, loss of the anti-proliferative function of vitamin D, as it has been found that human cultured keratinocytes exposed to calcitriol showed marked inhibition of growth and accelerated maturation (117). Moreover, as inflammation and angiogenesis represent cornerstones in the pathogenesis of psoriasis (118, 119), the loss of the anti-inflammatory and anti-angiogenic activity of vitamin D (108) could represent another explanation to the contribution of the vitamin D deficiency in psoriasis. As 1 α ,25-dihydroxyvitamin D₃ is known to suppress the Th1 and Th17 cell proliferation (69), as well as induce the Tregs (120), another proposed pathway through which vitamin D deficiency could share in the psoriatic predicament would be the unchecked proliferation of Th1 and 17 cells on one hand and unchecked inhibition of Tregs on the other hand. Topical treatment with calcipotriol has been shown to significantly decrease cutaneous levels of human beta defensins (HBD) 2 and HBD3 as well as IL-17A, IL-17F and IL-8, which play significant roles in psoriasis (121), further linking vitamin D deficiency to the pathogenesis of psoriasis.

Owing to this postulated role played by vitamin D in the pathogenesis of psoriasis, it is no wonder that it is one of the most popularly prescribed topical medications for this disease, singly or in combination with betamethasone, and numerous studies documented the efficacy and safety of using topical calcipotriol in the

treatment of cases of localized plaque psoriasis (122-126).

Acne and rosacea

Acne vulgaris is the most common skin disorder affecting millions of people worldwide. Inflammation resulting from the immune response targeting *Propionibacterium acnes* (*P. acnes*) has a significant role in acne pathogenesis. In a recent study, it has been demonstrated that *P. acnes* is a potent inducer of Th17, and that 1,25OH₂D inhibits *P. acnes*-induced Th17 differentiation, and thereby could be considered as an effective tool in modulating acne (127). Furthermore, sebocytes were identified as 1,25OH₂D responsive target cells, indicating that vitamin D analogs may be effective in the treatment of acne. In another recent study, the expression of inflammatory biomarkers have been shown to be influenced by treatment with vitamin D in cultured sebocytes, but not through VDR (128).

In the same spectrum of acne, another study demonstrated relatively high serum levels of vitamin D in patients with rosacea which is a common chronic skin condition affecting the face, in comparison with controls, suggesting that increased vitamin D levels may lead to the development of rosacea (129).

Hair loss

The role of vitamin D in hair might be explained by the fact that an optimal concentration of vitamin D has been suggested to be necessary to delay the aging phenomena, including hair loss (130). Recently it has been shown that 1,25OH₂D/VDR promotes the ability of β -catenin to stimulate hair follicle differentiation (131). Moreover extensive data from animal models clearly show that the VDR activation plays an important role in the hair follicle cycle, specifically anagen initiation (132). Interestingly, in VDR ablated mice it did not seem that normalization of mineral ion homeostasis by a diet high in calcium and phosphorous prevented alopecia suggesting that the mechanism for alopecia is unrelated to mineral levels but rather to the vitamin D levels (133). Furthermore, recent data suggested that VDR regulates directly or indirectly the expression of genes required for hair follicle cycling, including the hedgehog signaling pathway (134).

A recent study conducted on eighty female patients demonstrated that low serum vitamin D₂ is associated with both common types of hair loss in females namely; telogen effluvium and androgenetic female pattern hair loss. It was suggested that screening for vitamin D level and supplementation with vitamin D in cases with deficiency would be beneficial in the management of these conditions (135).

In contradistinction to the proposal of the important role played by vitamin D in hair loss, a placebo-controlled trial on 26 patients showed that calcipotriol did not affect the telogen to anagen ratio after 6 weeks of treatment in patients with scalp psoriasis. It is to be noted that the optimal effect of calcipotriol on psoriasis was not seen until 8 weeks, thus, follow up might have been too brief to detect an effect of calcipotriol on hair loss (136). Furthermore, a cross sectional study of 296 healthy men was done to explore a possible association between male pattern baldness and serum 25-hydroxyvitamin D levels. The severity and extent of the

baldness did not appear to be associated with serum 25-hydroxyvitamin D levels (130). This raises the speculation about the real value of vitamin D levels in hair loss, and whether the story could be intrinsic, closely related to the receptor itself rather than to the level of vitamin D.

Vitiligo

Vitiligo is a common pigmentary disorder characterized by well-demarcated depigmented patches or macules of different shapes and sizes and is caused by the destruction of functional melanocytes in the epidermis (137).

Vitamin D protects the epidermal melanin unit and restores melanocyte integrity via several mechanisms including controlling the activation, proliferation, migration of melanocytes and pigmentation pathways by modulating T cell activation, which is apparently correlated with melanocyte disappearance in vitiligo. The mechanism through which vitamin D exerts its effects on melanocytes is not yet fully understood. Vitamin D is believed to be involved in melanocyte physiology by coordinating melanogenic cytokines [most likely endothelin-3 (ET-3)] and the activity of the SCF/c-Kit system, which is one of the most important regulators of melanocyte viability and maturation (138). Furthermore, a proposed mechanism involving vitamin D in the protection of vitiliginous skin is based on its antioxidant properties and regulatory function toward the reactive oxygen species that are produced in excess in vitiligo epidermis (139). Another point is that the active form of vitamin D reduces the apoptotic activity induced by UVB in keratinocytes and melanocytes (140), that has been reported to remove melanocytes from the skin (141). Moreover, vitamin D might exert immunomodulatory effects by inhibiting the expression of IL-6, IL-8, TNF- α , and TNF- γ , modulate dendritic cell maturation, differentiation, and activation as well as induce the inhibition of antigen presentation [65], thereby dampen the autoimmune pathway incriminated in the pathogenesis of vitiligo.

It is still unknown if vitamin D deficiency plays a role in causing vitiligo, as it does in other autoimmune diseases. In 2010 Silverberg and Silverberg (142) assessed serum 25-hydroxyvitamin D (25(OH)D) levels in 45 patients with vitiligo and it appeared that 55.6% were insufficient (22.5–75 nmol/L) and 13.3% were very low (<22.5 nmol/L) a finding that was re-demonstrated by others (143). However, another study showed no correlation between 25(OH)D and vitiligo (144).

Regardless the existing controversy, topical vitamin D₃ analogs are members of the armamentarium of therapeutic modalities for vitiligo. The use of vitamin D analogs in combination with PUVA and topical calcipotriol for the treatment of vitiligo was first reported by Parsad et al. (145). Subsequently, a number of studies have reported on the treatment of vitiligo with vitamin D analogs alone or in combination with ultraviolet light or corticosteroids to enhance repigmentation (142, 146, 147) with some contradictory results (148-150).

Pemphigus vulgaris and bullous pemphigoid

Pemphigus vulgaris and bullous pemphigoid are potentially fatal autoimmune bullous disorders caused by keratinocyte acantholysis as a result of pathogenic antibody production by B cells. Vitamin D, through its participation in several immune modulatory functions including B cells apoptosis, Th2 cell differentiation, apoptotic enzyme regulation and Tregs functions, may be actively involved in the immune regulation of such diseases. Several recent studies demonstrated that patients with pemphigus vulgaris and bullous pemphigoid have significantly lower serum vitamin D levels in comparison with controls regardless age, body mass index or pattern of sun exposure (151, 152). In addition, it was suggested that this lower level of vitamin D might account for the increased prevalence of fractures in such patients and therefore should be taken into consideration in patients who must be given corticosteroids (152).

Atopic dermatitis

Atopic dermatitis (AD) is a common chronic inflammatory type of eczema. Several studies have shown initial epidermal barrier dysfunction with subsequent immune activation as the underlying mechanism. Animal studies, case reports, and randomized clinical trials have suggested that vitamin D, through various mechanisms including immunomodulation, may alleviate the symptoms of AD. The majority of these studies indicate an inverse relationship between the severity of atopic dermatitis and vitamin D levels. Furthermore, studies have shown that, in individuals with AD who are deficient in vitamin D, repletion of vitamin D results in improvement and decreased severity of the disease (153, 154).

Conclusions

In conclusion one could clearly sense the unique relationship that entangles vitamin D to dermatology. On one hand, our skin is one source for this important vitamin and on the other hand all available data point to its important impact on the health of our skin and the involvement of its deficiency in the pathway of many dermatological diseases. Several factors are responsible for maintaining it in optimum levels; therefore sunny climates are by far not a guarantee for providing a "comfort zone" regarding the possibility of this vitamin deficiency, a concern documented by several epidemiological studies carried out in areas close to the equator (155-158). On the basis of currently available data, it is clear that supplemental vitamin D should be the preferred recommendation toward achieving its normal serum levels, thereby avoiding the deleterious effects accompanied by its deficiency. Still more research is needed to unravel its complicated ties to dermatological diseases and create clear guidelines and recommendations for its supplementation.

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PHILOLOGICAL SCIENCES

ARTISTIC REFLECTION OF REAL-LIFE FACTS IN THE PLAYS OF ILYAS EFENDIYEV

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Abstract

In the history of Azerbaijani literature, one of the personalities who played an important role in the development of dramaturgy, prose and journalism since the middle of the 20th century was Ilyas Efendiyev. In addition to continuing the realistic traditions of national literature, he also gave impetus to the formation of new artistic and aesthetic qualities. The writer's creativity has become an expression not only of the literary process, but also of the socio-moral landscape of the era.

Ilyas Efendiyev is one of the personalities who formed an important stage in the development of Azerbaijani literature. His works have left an indelible mark on the psychological depth of national dramaturgy, the formation of modern artistic language and the artistic expression of human spirituality in art. The writer's creativity remains relevant for our modern era, both from a literary and moral-aesthetic point of view.

Ilyas Efendiyev, in addition to continuing the realistic traditions of national literature, gave impetus to the formation of new artistic and aesthetic qualities. The writer's work has become an expression not only of the literary process, but also of the socio-moral landscape of the era.

Keywords: Ilyas Efendiyev, realism, national literature, truths of life, play, dramaturgy, creative manner, etc.

Ilyas Efendiyev (1914–1996) took his first steps in literature in the genre of short stories, but later became known more as a playwright. One of the main innovations he brought to literature was the ability to delve into the depths of human psychology, a dramaturgical model based on internal monologue and situational tension. In Efendiyev's works, simple events of everyday life are filled with deep philosophical and spiritual content.

The main themes in the writer's works are values such as human dignity, moral purity, conscience, love and freedom. He presents human character under the influence of the social environment, and also brings to the fore the moment of moral choice of each hero. This aspect is clearly visible in his plays such as "You Are Always With Me", "The Song Remained in the Mountains", "The Atayevs' Family", "The Battle of Lovers in Hell" (1, p.4).

In Azerbaijani literature, Ilyas Efendiyev (1914–1996) is one of the artists who opened a new stage in the development of dramaturgy in the second half of the 20th century. He is known as a writer who penetrated the depths of human psychology in national dramaturgy and artistically reflected the socio-moral problems of the time with real shades of life. The events, images and situations in Efendiyev's plays present a real picture of Azerbaijani society, fully showing the relationships between people and time. One of the main poetic features of Ilyas Efendiyev's dramaturgy is realism. The writer presents life material as it is, without idealizing it, but with artistic generalization. In plays such as "You Are Always With Me", "The Atayev Family", "Days of Joy", "The Song Remained in the Mountains", "Strange Boy", the fate of people from different walks of life, their spiritual searches, conflicts and relationships with the social environment are vividly reflected.

The main idea for Efendiyev is the issue of human moral integrity and inner freedom. He reveals the inner

world of his heroes with psychological details, presenting them against the background of real life contradictions.

Efendiyev brings to the center of dramaturgy such problems as the moral crisis arising in the process of development of society, the undermining of the family institution, alienation in human relations, the clash of modernity and tradition. For example, in the play "The Atayevs' Family", intra-family relations, intergenerational conflict and the concept of moral responsibility are realistically developed. Here the writer shows that social well-being does not provide a person's moral comfort, and the loss of moral values leads to individual tragedies.

In the play "You are always with me", the author realistically describes the psychological picture of the post-war years, the moral turmoil of a person related to memory and love. The work presents the socio-cultural realities of the era in unity with personal feelings.

The play focuses on the impact of war on human psychology and social relations. The work shows both individual and collective tragedy: the heroes face losses, memories and mutual responsibilities. Efendiyev formulates the idea here as follows: historical and social difficulties can change the inner world of a person, but they retain the spiritual integrity and power of love.

The heroes of the play are depicted with realistic portraits. They reflect the person of the modern era, full of internal contradictions and psychological complexities. The main character is a person who has gone through wars and losses, but has preserved his spiritual stability. His internal dialogues show a person being caught between hope and fear. The female image in Ilyas Efendiyev's play acts as a family, love and moral support. She also performs the function of a bridge between the past and the future. The supporting characters in the work reflect different layers of society

and the social realities of the time. Their dialogues illuminate social conflicts and people's relationships with each other. Each of the characters enhances both the dramatic tension and artistic meaning in the play (2, p.17).

As for the artistic features of the work, Efendiyev presents the events as they are, far from artificial idealism. The social and moral crisis of the post-war society is reflected in the characters. The internal monologues and mutual relations of the heroes accurately show their psychological state. The conversations of the characters are simple, natural and convincing, reflecting the social and moral state of each character. In the work, the author symbolically shows the impact of war and losses through memories, music and everyday events.

Although the structure of the play is based on the principles of classical dramaturgy, Efendiyev enriches it with psychological realism. Events develop sequentially, but the author's attention is mainly focused on the inner world of the heroes. This gives the work both dramaturgical and philosophical depth.

The play "You Are Always With Me" is a brilliant example of Ilyas Efendiyev's art of reflecting real life realities in artistic form. By realistically presenting human destinies, moral and psychological difficulties after the war, the author brought a valuable example of psychological realism to Azerbaijani dramaturgy (3, p.38). The play emphasizes the importance of preserving the spiritual integrity of a person in both an individual and social context.

The heroes of Ilyas Efendiyev are not artificial, but living portraits of society. They live with the worries, desires and contradictions of everyday life. The writer preserves reality in their manner of speaking, behavior, and feelings. This is especially evident in the play "The Song Remained in the Mountains". Here, the bitter reality of the war years, losses and the unshakable will of man are expressed in poetic language.

Efendiyev also pays special attention to the psychological depth of female characters. In his plays, a woman is presented not only as an object of love, but also as a spiritual support, a personality standing at the center of family and society.

Ilyas Efendiyev's language is simple, but has an emotional impact. He clearly shows the social status, way of thinking, and psychological state of the characters through colloquial language. The author's stage speech is based on natural dialogues in life, which gives the plays sincerity and credibility. Efendiyev combines the principles of classical dramaturgy with the psychological depth of modern dramaturgy in the artistic structure.

Ilyas Efendiyev's plays reflect the stages of social and moral development of Azerbaijani society as an artistic chronicle. In his work, real life realities are presented not only as a subject of observation, but also as an object of artistic and philosophical analysis. In Efendiyev's dramaturgy, the clash of a person's inner world and the social environment has created a new qualitative stage in the development of the national theater.

Efendiyev presents the spiritual world of man, social and moral problems, as well as the values of patriotism, family, friendship and labor on a dramatic level, giving an educational message to the audience. In Efendiyev's plays, the educational significance is manifested in several aspects. In the plays, the internal struggle of the heroes, their moral dilemma and the process of choice provide the audience with a moral example. For example, in the play "You Are Always With Me", the psychological and moral revival of the heroes who have gone through the war teaches the values of humanity, patience and conscience to young people (4, p.27).

In the work "The Atayevs' Family", the issue of intergenerational conflict and the preservation of family values is shown through dramatic means. The plays emphasize the importance of properly building family relationships, and children are educated in a sense of respect for the family and responsibility.

The author's plays were mainly written against the backdrop of war and social crisis. Patriotism, social responsibility and labor values are one of the main themes in these works. In the play "The Song Remained in the Mountains", the consequences of war and the support of people for each other, as well as the importance of national unity and solidarity, are instilled in the audience.

In Efendiyev's plays, he shows the consequences of right and wrong, justice and injustice through the choices of the heroes. This educates the audience's thinking and develops their ability to judge ethically and morally.

Ilyas Efendiyev uses various artistic means to realize the educational goal. The inner world of the heroes is presented clearly and convincingly for the audience. This develops a sense of empathy and understanding in the younger generation. Social and moral issues are clearly visible through simple and natural dialogues. Also, motifs such as war, loss, and memories strengthen the educational message.

Ilyas Efendiyev's plays are an important example of the educational function in Azerbaijani dramaturgy. They are not only intended for performance, but also serve the spiritual and moral development of the younger generation. In his plays, Efendiyev presents the inner world of man, family, friendship, patriotism and moral choices in realistic and artistic-philosophical shades, forming thoughts and feelings in the audience. From this point of view, his works are evaluated as an important tool for both theater and educational work (5, p.47).

Efendiyev's dramaturgy brought a modern breath to Azerbaijani theater art. Unlike the classical concept of conflict, he brought internal drama and psychological contradictions to the fore. In his works, stage events are presented in the form of a moral struggle rather than an external confrontation.

His heroes no longer fit into simple categories such as "positive" and "negative"; they listen to the voice of their conscience in the face of life's complex dilemmas. The writer's language is sincere, natural and rich in artistic expression.

Efendiyev's dramaturgy, especially in the 1960s–80s, laid the foundation for modern psychological theater on the Azerbaijani stage. His plays, while continuing the traditions of Jafar Jabbarli, also reflected the aesthetic searches of the new era.

Ilyas Efendiyev also showed fruitful creativity in the field of prose. In his stories and narratives such as “Don't Look Back, Old Man”, “The Tale of Valehin with a Yellow Shirt”, “The Day of the Murder”, the writer brought to the forefront the inner world of man, values such as conscience and responsibility. His prose language is poetic, emotional and realistic (6, p.51).

In his journalistic articles, the writer attached special importance to the role of literature and art in the moral education of the people, and to the fact that art should serve man.

Ilyas Efendiyev's creativity is not limited to his time. His artistic and aesthetic principles have become a school for subsequent generations of writers. Efendiyev's influence is also clearly felt in the work of authors such as Anar, Elchin, and Isi Malikzade.

He turned the elegance and inner freedom of the spiritual world of man into the main value of literature, and strengthened the line of humanism and aesthetic realism in Azerbaijani literature.

Ilyas Efendiyev is one of the personalities who formed an important stage in the development of Azerbaijani literature. His works left an indelible mark on the psychological depth of national dramaturgy, the formation of modern artistic language, and the artistic expression of human spirituality in art. The writer's work remains relevant for our modern era, both from a literary and spiritual-aesthetic point of view.

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Ahmadova L.

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In the 21st century, globalization has had a significant impact on literature in terms of both technological, thematic and aesthetic aspects. Modern literature is not limited to national and regional borders, but has become a platform for the expression of various cultures and social problems on the global stage. It is possible to emphasize that in the modern era of ongoing globalization, the role of literature is not only entertaining and aesthetic, but also an important tool in the formation of intercultural dialogue and social consciousness.

Literature in the 21st century is developing under the influence of rapidly changing social, cultural and technological conditions. Globalization, digitalization, multiculturalism and modern reader demands are fundamentally changing the themes, genres and styles of literature. The rapid change in literary trends leads to the emergence of new stylistic forms both in the creative strategies of authors and in the perception of readers.

Rapidly developing technology is characterized as an era of globalization and intercultural interactions. These processes have had a profound impact not only on the economic, political and social spheres, but also on literature. As a result of globalization, cultures from different regions of the world are interacting more closely with each other, as a result of which the themes, genres and ways of dissemination of literature are changing fundamentally.

Globalization has brought to literature, first of all, a diversity of subjects. Modern writers no longer deal only with national and regional problems, but also with global issues - migration, emigration, ecological crises, global justice and human rights. For example, authors such as Chimamanda Ngozi Adichie, Haruki Murakami and Elena Ferrante illuminate in their works the new challenges faced by individuals and societies in a globalized world.

Keywords: world literature, globalization, modern literature, digitalization, multicultural values, etc.

World literature is a broad field that encompasses the written and oral literary heritage of various peoples, and is an expression of human thought, culture and emotions. It does not consist only of the literature of a particular country or people, but unites the literary creativity of all mankind and plays an important role in the formation of global cultural relations. The concept of world literature encompasses both classical works and literary examples of the modern era and has gone through various stages throughout its historical development.

When summarizing the history of literary development, the role of ancient oral literature - epics, myths and lyric poems - is great at the first stage. During this period, people used mainly oral style to convey their life experiences and culture. The emergence of written literature in ancient Mesopotamian, Egyptian, Indian and Chinese cultures is important in terms of preserving cultural heritage in the history of mankind and transmitting it to future generations.

In the Middle Ages, religious and spiritual themes dominated world literature. Religious texts and moral treatises were widespread in European, Asian and Middle Eastern literature, and epic poems and lyric poems also developed during this period. In the 13th–18th centuries, the ideas of humanism and the Enlightenment formed the main themes of literature, and the social position of man and personal freedom came to the fore.

In the 19th century, the industrial revolution and social changes brought new themes to literature. Genres such as realism, romanticism, and naturalism became the main directions of the literary process. In the 20th century, postmodernism, experimental literature, and global literary movements expanded the boundaries of

world literature and contributed to intercultural dialogue. In the modern era, technology, globalization, and digital media have accelerated the spread of literature and created opportunities for the emergence of new styles and genres (1).

Thus, world literature has been formed throughout its historical development in accordance with the changing needs of human thought, culture, and society, and has been distinguished by its unique characteristics in each era. It is not only satisfied with providing aesthetic pleasure, but also has significance as an indicator of the social, philosophical, and cultural development of humanity.

The 21st century is characterized by a period of rapidly developing technology, globalization, and intercultural interactions. These processes have had a profound impact not only on the economic, political, and social spheres, but also on literature. As a result of globalization, cultures from different regions of the world are interacting more closely with each other, as a result of which the themes, genres and ways of dissemination of literature are fundamentally changing.

Globalization has brought to literature, first of all, a diversity of topics. Modern writers no longer deal only with national and regional problems, but also with global issues - such as migration, emigration, environmental crises, global justice and human rights. For example, authors such as Chimamanda Ngozi Adichie, Haruki Murakami and Elena Ferrante illuminate in their works the new challenges that individuals and societies face in a globalized world.

On the other hand, globalization has also affected the methods of dissemination of literature. Thanks to digital media and the Internet, works reach a wider audience, and translation and distribution opportunities

are increasing. At the same time, new genres such as multimedia literature and interactive stories have emerged, which are closely related to the technological side of globalization. This makes literature not only a work to be read, but also a cultural product to be experienced.

Globalization also promotes intercultural dialogue in literature. Writers from different countries learn about each other's cultures, which leads to both the enrichment of literary styles and the expansion of reader perception. Postcolonial and feminist approaches to criticism have become even more relevant in the context of globalization, highlighting the polyphonic and multicultural nature of world literature.

In the 21st century, globalization has had a significant impact on literature from both a technological, thematic and aesthetic perspective. Modern literature is not limited to national and regional boundaries, but has become a platform for the expression of different cultures and social problems on the global stage (2). It can be emphasized that in the modern era of globalization, the role of literature is not only entertaining and aesthetic, but also an important tool for intercultural dialogue and the formation of social consciousness.

Literature in the 21st century is developing under the influence of rapidly changing social, cultural and technological conditions. Globalization, digitalization, multiculturalism and modern reader demands are fundamentally changing the themes, genres and styles of literature. The rapid change in literary trends leads to the emergence of new stylistic forms, both in the creative strategies of authors and in the perception of readers.

The main role in the change of literary trends belongs to the principles formed by literary movements such as postmodernism and post-postmodernism. In these movements, linear narrative structure, hero-centered approach and classical genre rules give way to experimental structures, metafiction, polyphony and intertextual approaches. As a result, authors invite the reader not only to follow the story, but also to analyze the text, to understand its different levels.

The emergence of new stylistic forms is also associated with the integration of technology into literature. Digital platforms, e-books, interactive stories and multimedia works expand the traditional boundaries of literature. Such works transform the reader from a passive receiver to an active participant and turn literature into an experienced phenomenon. At the same time, social media and online literary platforms allow authors to quickly publish their work and instantly connect with a global readership.

The rapid change of literary trends also affects the richness of the subject. Global issues such as social justice, gender equality, environmental problems, migration and globalization are among the main themes in contemporary literature. Under the influence of different cultures, new narrative techniques, poetic forms and dramaturgical structures are formed, which strengthens the polyphonic and multicultural character of literature.

Consequently, the rapidly changing trends of literature in the 21st century and the emergence of new stylistic forms both expand the possibilities of creativity

and strengthen the interactive relationship between the reader and the author. This process reveals literature not only as an aesthetic product, but also as a dynamic phenomenon in a social, cultural and technological context.

Since the second half of the 20th century, major changes have occurred in literature, and postmodern trends have come to the fore, in contrast to classical realist approaches. Postmodernism is an aesthetic movement in which certain rules, linear story structure and the concept of objective truth are questioned in literature. This trend has opened up new possibilities of experience and creativity for both the author and the reader (3).

The experimental novel is one of the main forms of postmodern literature. In this genre, authors experiment with traditional novel structures, moving away from the hero-centered plot line, using different perspectives, time jumps, and unconventional storytelling techniques. For example, James Joyce's *Ulysses* and Thomas Pynchon's *Gravity's Rainbow* are examples of experimental novels. In these works, the boundaries of language, plot, and structure are expanded, and the reader is a more active participant in constructing the story.

Metafiction, on the other hand, is a technique that expresses literature's own thinking. In metafiction, the author provides intratextual comments about the text, reveals the construction of the story, and invites the reader to accept the artificial structure of the story. This approach leads the reader to a more conscious perception of the difference between literary illusion and reality. Metafiction is also one of the critical elements of postmodernism, because it questions the boundaries of literature and traditional genre rules.

In modern world literature, postmodernism, the experimental novel, and metafiction complement each other. They present literature not only as a means of storytelling, but also as a means of thought, social, and cultural analysis. The influence of these trends and techniques is clearly visible in the works of authors as diverse as Salman Rushdie, Don DeLillo, Italo Calvino. They blur the boundaries between reader and author, making literature more dynamic, interactive, and multi-voiced.

As a result, postmodernism, the experimental novel, and metafiction mark a new stage in the development of world literature. These trends and techniques do not limit themselves to presenting literature as an aesthetic product alone, but also open up vast opportunities for intercultural dialogue, social awareness, and reader participation.

In the 21st century, literature has begun to move beyond the traditional book format and make extensive use of technology. Multimedia and digital literature are among the most striking examples of this process. This type of literature does not consist solely of written text; it combines visual elements, sound, animation, interactive graphics, and other multimedia components to provide the reader with a richer and more complex experience.

Multimedia literature emphasizes the interactive experience of the reader. The work is not just read, but

also felt and experienced in a reciprocal way. The technologies used in such works directly affect the plot, character development, and aesthetic impact of the story. For example, interactive stories, visual novels, and multimedia poetry invite the reader to participate as an active participant rather than a passive recipient.

Digital literature, on the other hand, encompasses literature distributed via the internet, e-books and online platforms. Blogs, online narratives, electronic literature journals and interactive writing projects are examples of digital literature. One of the advantages of digital literature is its global distribution capabilities; the author can instantly deliver his work to any point in the world. This strengthens intercultural dialogue in the era of globalization and makes it easier to reach different groups of readers(4).

Multimedia and digital literature also expands the boundaries of traditional genres. Classic genres such as poetry, drama and novels are no longer based solely on text; visual, audio and interactive elements complement the content of the work, enriching the reader's experience. This makes literature more dynamic, multi-voiced and relevant to the demands of the modern era.

As a result, multimedia and digital literature play an important role in the development of 21st century literature. It strengthens the interactive relationship between reader and author, turns literature not only as an aesthetic product but also as an experiential phenomenon and promotes intercultural dialogue in a globalized world.

In the 21st century, poetry and drama have begun to explore new aesthetic and stylistic possibilities, moving away from their traditional forms. In modern times, literature offers ample opportunities not only as a means of expressing stories and feelings, but also as a means of creating interactive relationships with readers and audiences. This process has created conditions for the introduction of new forms and styles into the development of poetry and drama.

New forms and styles in poetry are mainly related to increasing the flexibility and visual capabilities of language. Modern poets are creating new genres such as free verse, visual poetry, performative poetry, and multimedia poetry, breaking away from the rules of classical meter and rhyme. Visual poetry, for example, allows the reader to perceive the meaning of a poem not only from the words themselves, but also from their spatial organization and graphic structure. Performative poetry, on the other hand, enhances the aesthetic and emotional impact of poetry by involving the reader in the experience as an actor.

New forms and styles in dramaturgy, on the other hand, expand the classical structures of theater. Modern playwrights use, for example, non-linear plot, interactive stage, multimedia performance, and improvisation techniques. These approaches provide active interaction with the audience and change the traditional concept of the performance. The transition from literary text to the performance process leads to the emergence of both visual and emotional elements in dramaturgy.

The introduction of new forms and styles in contemporary poetry and dramaturgy is also important in terms of the expression of social and cultural issues.

Gender, race, migration and environmental issues are highlighted in contemporary poetry and dramaturgy (5). This process strengthens not only the aesthetic but also the social function of literature. Contemporary authors and directors, such as Sarah Kane, Caryl Churchill and Anne Carson, include both formal innovations and deep spiritual and social themes in their works.

Literature is not only an aesthetic and entertaining phenomenon in human society; it is also a social and cultural tool that plays an important role in the formation of human behavior and culture. It has the ability to influence a person's inner world, way of thinking, moral principles and social relations. Throughout history, literature has played an important role in the formation of both individual and collective behavior.

Through literature, people learn about different life experiences and cultures, perceive different perspectives and develop empathy skills. For example, novels, stories and dramas introduce the reader to different personalities and social environments, and allow them to understand their decisions, feelings and behaviors. This process strengthens a person's social consciousness and cultural identification.

Literature also plays an important role in the protection and transmission of the moral and ethical values of society. Classical and modern literary examples introduce people to values such as justice, compassion, conscience and human rights, and strengthen the normative framework of social behavior. In this regard, literature acts as a guarantor of both individual development and social balance.

Literature has an impact on the formation of culture both at the global and national levels. The literary heritage of different peoples conveys their language, history, customs and values to future generations. At the same time, modern world literature, under the influence of globalization, creates a dialogue between different cultures, creating conditions for understanding different social and cultural perspectives. This shapes the reader's attitude to both national and global culture.

The influence of literature on human behavior and the formation of culture has also expanded with the development of technology. Digital literature, interactive stories and multimedia poetry offer readers a more dynamic and participatory experience, making the process of studying culture and modeling social behavior more effective.

Literature is not only an aesthetic and entertaining art form; it is also an important tool for understanding different cultures. People get to know the lifestyle, traditions, values and way of thinking of other countries and peoples closely only through literature, and develop empathy and cultural sensitivity skills. This feature makes literature one of the main tools of global intercultural dialogue.

Literature introduces the unique characteristics of different cultures, introducing the reader to the worldview and social values of that culture. The images, events and symbols in novels, short stories, dramas and poetry reflect both historical and contemporary aspects of the culture. For example, Chinua Achebe's *Things Fall Apart* introduces Nigerian and Igbo

cultures, allowing the reader to become familiar with different social structures and traditions.

The role of literature in understanding different cultures is not limited to national borders. In the era of globalization, world literature allows readers to compare different cultures, see similarities and differences. Contemporary writers, such as Haruki Murakami and Elena Ferrante, present Japanese and Italian cultures to readers from different perspectives, strengthening their intercultural empathy and understanding.

Literature also plays an important role in eliminating cultural stereotypes and misconceptions. Works that present the lives of different peoples and societies through realistic and subjective experience create conditions for the development of intercultural dialogue and mutual respect in the reader. In this regard, literature is an effective tool in shaping both intercultural and social understanding.

In the digital era, there are factors that further expand the intercultural role of literature. E-books, online literary platforms, and multimedia works make it easier for readers to get acquainted with cultures from different corners of the world. This, in turn, accelerates the mutual understanding of different cultures in the era of globalization and enriches the reader's perception.

Consequently, literature is a key tool in shaping human behavior, developing social consciousness, and preserving cultural values. It supports both individual development and contributes to strengthening the cultural and social structure of society.

Literature plays a central role in understanding different cultures. It increases the reader's empathy and cultural sensitivity skills, eliminates stereotypes, and strengthens intercultural dialogue in a globalized world. In modern times, this impact has become broader and more diverse with the interactive and digital capabilities of literature.

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THE DYNAMICS OF EFFECTIVE LANGUAGE TEACHING AND LEARNING IN THE EFL CLASSROOM

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Abstract

The numerous components that contribute to effective language instruction and learning in English as a Foreign Language (EFL) classrooms are examined in this article. It focuses at important pedagogical strategies, the function of teacher-student contact, and the influence of learner motivation and autonomy. This study describes how a combination of communicative activities, explicit grammar instruction, and cultural integration can create a more stimulating and effective learning environment. It does this by drawing on recent research. The importance of ongoing evaluation and feedback in improving language acquisition is also highlighted in the conversation. In the end, this paper offers suggestions for improving EFL training to accommodate students' various demands and encourage successful language acquisition.

Keywords: EFL, language teaching, learner autonomy, communicative approach, motivation

In light of recent developments in pedagogical research and the growing demands of global communication, the field of teaching English as a foreign language (EFL) continues to evolve dynamically. From individual learner traits and cognitive types to instructional design, classroom management, and sociocultural context, effective language teaching and learning are complex processes influenced by many interrelated aspects. Fostering communicative competence and intercultural understanding is just as important as imparting language knowledge in many EFL contexts (Richards & Rodgers, 2014). In order to promote genuine conversation and involvement beyond memorization, educators must design dynamic, learner-centered environments.

The numerous variables that affect how effective EFL classes are are examined in this article. It specifically looks into how classroom dynamics might improve motivation and long-term performance, how teachers can use modern pedagogical approaches to foster meaningful learning, and how students can be encouraged to take ownership of their achievement. In order to provide a thorough understanding of the best practices in contemporary EFL teaching, it also takes into account the interplay between contextual factors, learner psychology, and instructional methodologies. In the end, knowing these relationships can assist teachers in designing linguistically stimulating, psychologically helpful, and culturally sensitive classrooms.

Methods

A thorough literature assessment of important publications in applied linguistics and second language instruction served as the foundation for this investigation. The review summarized results from international conference proceedings, groundbreaking books, and peer-reviewed journals that were published in the recent 20 years. Finding theoretical and empirical support for effective language education in EFL situations was the main goal of the data collection process. This was especially true when it came to communicative language teaching (CLT), task-based learning (TBL), explicit grammar instruction, learner autonomy, and motivation.

Through the use of specific keywords such "communicative competence," "learner-centered teaching," "EFL motivation," and "language learning strategies," sources were obtained from scholarly databases like Scopus, ERIC, and Google Scholar. Studies with certain methodological rigor, repeatable results, and applicability to secondary or postsecondary EFL instruction were given priority in the selection criteria. Finding recurrent pedagogical patterns, contrasting various teaching philosophies, and analyzing their effects on student involvement and academic performance were all part of the analysis. The contextual diversity of the research was also taken into consideration, since socio-economic, institutional, and cultural factors frequently influence language teaching methods. It was feasible to identify the essential components that contribute to successful and long-lasting EFL learning results thanks to this thorough review.

Results

A number of interconnected dynamics that are fundamental to successful EFL teaching and learning are shown by the literature synthesis.

1. Communicative Competence and the Function of contact: The communicative approach, which emphasizes meaningful contact as the method and end aim of learning, continues to be a prevalent framework (Brown, 2001). Students in communicative classes participate more actively, gain self-assurance, and become more fluent in using English in everyday situations. However, research indicates that in order to guarantee accuracy and syntactic complexity, communicative activities should be accompanied by explicit grammar instruction (Nassaji & Fotos, 2011). Learners risk making irreversible mistakes or reaching a plateau in their progress if they don't receive structured attention to form. It has been particularly successful to incorporate grammar into communicative contexts using focus-on-form strategies.

2. Learner Autonomy and Self-Regulation: Promoting learner autonomy—encouraging students to create personal objectives, evaluate themselves, and take ownership of their progress—is a recurring subject

in several research (Little, 2007). Through self-directed study and introspection, autonomy turns passive learners into active participants who participate outside of the classroom. By offering direction, criticism, and learning techniques, teachers who take on a facilitative role assist students in becoming more self-reliant, which promotes long-term language retention and life-long learning habits.

3. Teacher-Student Interaction and Classroom Climate: Supportive teacher-student connections that encourage candid communication, emotional safety, and intellectual challenge are hallmarks of effective classrooms. Teachers who employ scaffolding, meaning negotiation, and constructive criticism help students assimilate information more deeply and gain confidence. Additionally, these settings lessen anxiety, which is one of the main psychological obstacles to learning a second language.

4. Motivation and Engagement: Determination is frequently emphasized in the literature as a crucial factor in determining success. Perseverance and greater accomplishment levels are associated with intrinsic motivation, which is derived from interest, enjoyment, and personal relevance. By creating assignments that are interesting, culturally relevant, and suitably difficult, teachers can increase student motivation. Using project-based work, technology-based resources, and real-world materials helps maintain motivation and offers practical communication benefits.

5. Cultural Integration: Integrating cultural components into the curriculum contextualizes language learning and increases its significance while also improving intercultural competency. In addition to encouraging empathy and curiosity, exposure to literature, movies, and conversations on cultural norms broadens students' comprehension of the English-speaking world. Learners are further encouraged to use English genuinely by this integration, which links language to identity and global citizenship. When combined, these results demonstrate that a synergistic blend of communicative practice, organized instruction, autonomy-building, incentive, and cultural awareness produces effective EFL instruction rather than a single approach.

Discussion

The results show that rather than following a single instructional paradigm, successful EFL teaching and learning rely on a dynamic and multifaceted interaction of pedagogical concepts. The communicative method remains a strong basis, emphasizing the need of genuine language use and meaningful engagement. However, grammatical correctness and structural awareness must coexist alongside communicative ability in order for it to thrive. Learners attain both fluency and precision when explicit teaching is incorporated into communicative activities (Spada & Lightbown, 2008).

Furthermore, encouraging learner autonomy is a crucial tactic for maintaining development rather than an add-on objective. Learners who cultivate self-regulation

abilities and intrinsic motivation are better able to sustain their competency on their own in quickly evolving educational environments.

As a result, teachers become mentors and facilitators rather than information providers, helping students engage with language in a creative, critical, and reflective way. Constructivist ideas, which see learning as an active, socially mediated process as opposed to passive reception, are in line with this change.

Another important aspect of classroom dynamics is the relationship between the teacher and the students. Students feel appreciated and supported in an environment that is fostered by responsiveness, empathy, and effective communication. Students are more inclined to take chances, make errors, and grow from them in such an environment—actions that are crucial to learning a foreign language. Therefore, positive, detailed, and supportive feedback is essential for helping students view mistakes as chances for growth rather than failures.

Finally, the key to successful language learning is still motivation. Long-term engagement hinges on intrinsic and integrative motivation—the learner's sincere interest in the language and its culture—even when external motivators like tests or employment opportunities may start the learning process. By creating courses that relate English to students' own objectives, cultural experiences, and global awareness, teachers may foster this. By including real cultural content, such music, media, and social issues, learners are able to connect emotionally and see English as more than just an academic topic; it is a doorway to the world.

In conclusion, learner-centered, participatory, and diverse dynamics characterize effective EFL teaching and learning. Classrooms that combine communicative practice, explicit instruction, autonomy, incentive, and cultural involvement into a coherent and flexible structure are considered successful.

Teachers who adopt flexible, reflective, and research-informed approaches are better positioned to respond to learners' needs, nurture lifelong learning, and prepare students for real-world communication in a globalized context.

Conclusion

Effective teacher-student relationships, a variety of pedagogical approaches, and the development of learner autonomy and motivation all work together to provide effective language instruction and learning in EFL classrooms. The most successful method is a well-rounded one that incorporates conversational exercises with sparing explicit grammatical teaching. Additionally, creating an atmosphere where students feel empowered to take charge of their education, backed by helpful criticism and interesting material, greatly improves their competence and self-assurance. As the global demand for English continues to expand, understanding and adopting these patterns are vital for educators wanting to prepare learners for successful communication in an interconnected world. These dynamics will be further refined by ongoing research into learner expectations and instructor professional development, ensuring that teaching English as a foreign language stays effective, relevant, and transformative.

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TECHNICAL SCIENCES

SEARCHING OF AERODYNAMIC STRUCTURE AROUND BUILDINGS HAVING DISTINCT GEOMETRIC DESIGN PARAMETERS

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Abstract

Building aerodynamics is a vital interdisciplinary field that investigates the interactions between wind flow and building surfaces. In this study, flow structures around three building models with a 30° slope-10 cm × 5 cm × 5 cm, 5 cm × 5 cm × 10 cm, and 5 cm × 5 cm × 5 cm-were experimentally analyzed using Particle Image Velocimetry (PIV). Instantaneous velocity fields were measured, and time-averaged velocity distributions $\langle V \rangle$ and streamlines (ψ) were computed. The results show that wind separation at edges and corners generates recirculation zones along façades, side walls, rear, and roof regions, with elevated turbulence in the shear layers. Boundary layer thickness decreases toward the side edges, shortening downstream separation regions, while high turbulent kinetic energy is concentrated in wake vortices. Rotation of elongated building models significantly enlarged the wake vortices and influenced surrounding flow, whereas rotation of the cubic model had negligible effect. These findings highlight that building orientation strongly affects wake formation, particularly for elongated geometries.

Keywords: Building aerodynamics, Particle Image Velocimetry (PIV), Wake vortices, Flow separation

Introduction

Building aerodynamics is an important interdisciplinary research field that examines the effects of wind flow on building surfaces and their immediate surroundings. Increasing population density, intensive construction, and the proliferation of tall buildings with complex geometries underscore the critical role of wind loads in building performance (Blocken, 2014). Reyes and colleagues (2015) applied the Particle Image Velocimetry (PIV) method in a building–wind tower configuration to study airflow. To measure flow distribution by simulating natural ventilation, they conducted wind tunnel experiments with scaled models. Subsequently, the obtained PIV data were compared with RANS-based CFD simulations, and good agreement was observed in the comparison results. As a result, the study demonstrated that PIV is a reliable experimental validation tool for improving the design of wind towers. Furthermore, it recommended the use of the PIV technique in natural ventilation analysis. Sugahara et al. (2017) investigated the effects of installing air-cooled packaged air conditioners used in small and medium-sized buildings on the roof and on airflow in their study. The study used Particle Image Velocimetry (PIV) experiments conducted with scaled models to evaluate the effect of the position between the devices on airflow characteristics. Furthermore, the experimental data obtained were compared with Computational Fluid Dynamics (CFD) simulations, demonstrating that CFD can represent airflow close to the actual situation. The

results reveal that the optimal configuration of rooftop units is crucial for improving energy efficiency. Liu and et al. (2021) investigated the effects of horizontal and vertical ribs on local and global wind loads on the façades of tall buildings. The study analyzed models with six different rib configurations using experimental pressure measurements and high-frequency Particle Image Velocimetry (PIV). The results showed that horizontal ribs reduced the height of the leading stagnation point, while vertical ribs reduced turbulence intensity in the shear layer and near-wake region, thereby decreasing the fluctuating wind pressure on the side and leeward surfaces. Furthermore, the effect of the protrusions on the average wind force was evaluated by controlling the wake vortex length (L) and local wake width (W), and it was found that the optimal configuration is effective in reducing side wind forces. Liu et al. (2024) investigated natural convective flows caused by high heat loads in industrial buildings using a large-scale test rig and 2D PIV. The results showed that the air flow near the walls was anisotropic, the flow at the center was isotropic, and turbulence and fluctuations varied depending on the Rayleigh number. The study provides fundamental data for optimizing air distribution design in industrial buildings. Bagheri and et al. (2023) investigated the effects of natural ventilation on indoor air exchange rate and flow velocity in single-sided and cross ventilation modes. Experiments conducted using a water bath model and Particle Image Velocimetry (PIV) found that flow velocity was 18-32%

higher at low inlet levels in single-sided ventilation mode, but cross ventilation mode provided 28% higher flow when windows were positioned high. The tests showed that cross ventilation creates a higher air exchange rate than single-sided ventilation due to the lift force effect and that the air exchange rate increased by 71.75% when high-level outlet openings were used. Setio and et al. (2020) investigated wind loads on structures built between high-rise buildings in urban areas in Indonesia. Wind tunnel experiments using a simplified four-symmetric high-rise building model and Particle Image Velocimetry (PIV) were conducted to evaluate the effects of different attack angles and inter-building distances. The results showed that the interaction flow between buildings increased wind speed, that building distance altered cross-flow behavior, but that the attack angle did not affect the amplification factor. It was found that wind speed increased by 7-44% due to street canyons and that the highest amplification occurred at a 0° attack angle. Tominaga and colleagues (2015) investigated the airflow around isolated triangular-roofed buildings with different roof slopes. Wind tunnel experiments measured time-averaged velocity, turbulent kinetic energy, and pressure coefficient, followed by validation using RANS-based CFD simulations. The results showed that the simulations agreed well with the measured values for flow-direction velocities (15% deviation), but that transient vortex effects in the rear regions of the building could not be fully captured with steady RANS. Furthermore, it was found that the roof slope had a significant effect on the flow field around the building, and that the difference between slopes of 3:10 and 5:10 was greater than the difference between 5:10 and 7.5:10. Albuquerque and colleagues (2020) experimentally and numerically investigated pumped natural ventilation in an isolated building. Wind tunnel experiments and PIV measurements showed that pumped ventilation is a periodic and three-dimensional oscillatory phenomenon. In numerical simulations, LES accurately predicted ventilation rates, while URANS produced significantly lower values. The efficiency obtained with LES was found to be in the range of 0.60-0.75. Kim et al. (2019) experimentally investigated the **wind flow around two connected buildings**. Models with different gap distances were analyzed using **Particle Image Velocimetry (PIV)** and **Proper Orthogonal Decomposition (POD)**. Results showed that for side-by-side arrangement with a small gap, a single vortex street and biased flow formed, while a larger gap led to two independent vortex streets. In tandem arrangement ($\alpha = 90^\circ$), the shear layer street influenced the entire system, whereas for $\alpha = 0^\circ$, the gap distance significantly affected the flow patterns. When the gap was two-thirds of the building width, the maximum mean wind velocity around the buildings was observed.

Liu et al. (2023) investigated the effects of **horizontal ribs** on wind impact reduction for tall buildings using a **Large Eddy Simulation (LES)** approach under atmospheric boundary layer flow. Results showed that horizontal ribs significantly **suppress the formation of separation vortices** near the side walls and increase vortex size in the wake. The ribs obstruct vertical flow near the façade, creating small recirculation zones and localized flow concentration between adjacent ribs, which leads to notable changes in the near-wall flow pattern. These modifications in near-wall flow result in significant variations in **wind pressure distribution and wind forces**. Continuous ribs can induce a “zig-zag” pattern in the mean pressure along the building height and reduce fluctuating lift forces by up to 27%, whereas discrete ribs have relatively weak effects on wind forces. Han et al. (2022) investigated **thermal plumes from high-rise façades** under windless conditions using a scaled model and **PIV**. Results showed that vertical wind speed increases with height while temperature remains nearly constant, and horizontal air speed peaks near $y/D = 0.1$, with thermal effects confined to roughly half the building thickness.

Material and Method

In this study, experiments were conducted using Particle Image Velocimetry (PIV) within both closed-loop and open-surface water channels. The experimental setup was constructed from fiberglass and comprised two water reservoirs connected by a transparent acrylic test section. The test section measures 750 mm in height, 1000 mm in width, and 9000 mm in length. Water circulation between the reservoirs is maintained by a 15 kW centrifugal pump, whose rotational speed is controlled via a frequency-regulated drive, enabling experiments at varying flow rates. The pump draws water from the downstream reservoir and delivers it to the upstream reservoir.

To ensure uniform and stable flow within the test section, a honeycomb flow straightener was installed at the outlet of the inlet reservoir. Additionally, the connection between the inlet reservoir and the test section was contracted at a 2:1 ratio to minimize flow disturbances. The inlet reservoir also serves as a settling chamber, allowing water to pass through a flow regulation section before entering the test section, thereby improving flow uniformity for PIV measurements.

The system is equipped with a filtration unit to remove foreign particles and debris from the water in the reservoirs. To minimize thermal interactions between the water channel and the particle circulation system, the laboratory temperature was maintained at 22°C . Furthermore, to prevent interference from sunlight on the laser beam, the laboratory windows were covered with special blackout curtains. A schematic view of the test channel is presented in Figure 1 (Gölbaşı, 2015).



Figure 1. Test channel

The **Particle Image Velocimetry (PIV)** technique generally involves two main stages: **flow visualization** and **image processing**. To track the flow, small tracer particles are introduced into the experimental domain. These particles are illuminated twice in rapid succession by a light source positioned over the measurement plane. The time interval between consecutive illuminations is adjusted according to the **mean flow**

velocity and the **magnification scale**. During this interval, the particles move according to the local flow velocity, and the light they scatter is captured on two separate frames by a **high-resolution camera** positioned perpendicular to the light sheet. The recorded PIV images are subsequently digitized and transferred to a computer for further analysis. **Figure 2** illustrates the working principle of the PIV technique.

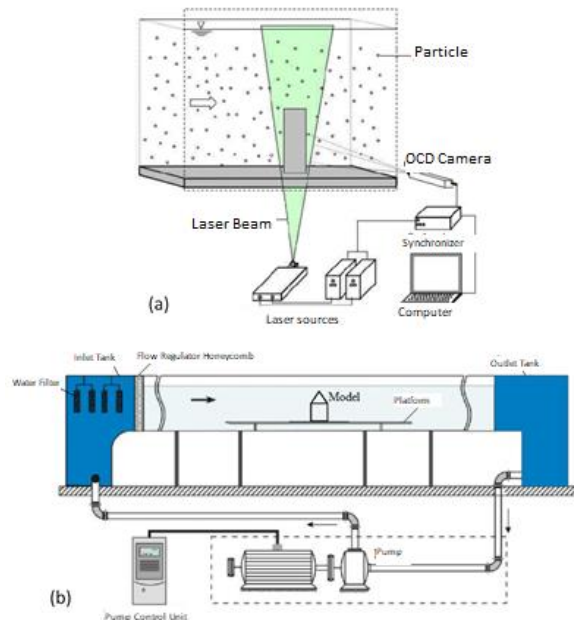


Figure 2. (a) PIV working principle (b) schematic view of the water channel (Gölbaşı, 2015)

In the experiments, **three different building models** fabricated from transparent acrylic were employed to investigate flow characteristics. The water level in the test section was maintained at a constant **0.45 m**, and the **front edge of the platform** was beveled to prevent flow disturbances. The models were positioned **1.5 m downstream of the channel inlet** to minimize turbulence effects. Experiments were conducted under conditions where the **free-stream flow velocity** was set to **210 mm/s**.

Top View Surface Measurements

As illustrated in Figure 3(a), the camera is positioned opposite the channel, while a laser is placed in front of the building to capture its top view. A mirror inclined at 45° is installed in front of the camera to complete the experimental setup. The positions of both the camera and the mirror are shown in Figure 3(b). The symmetry plane considered for the top view is taken at $y/H = 0$, as depicted in Figure 3(c) (Gölbaşı, 2015).

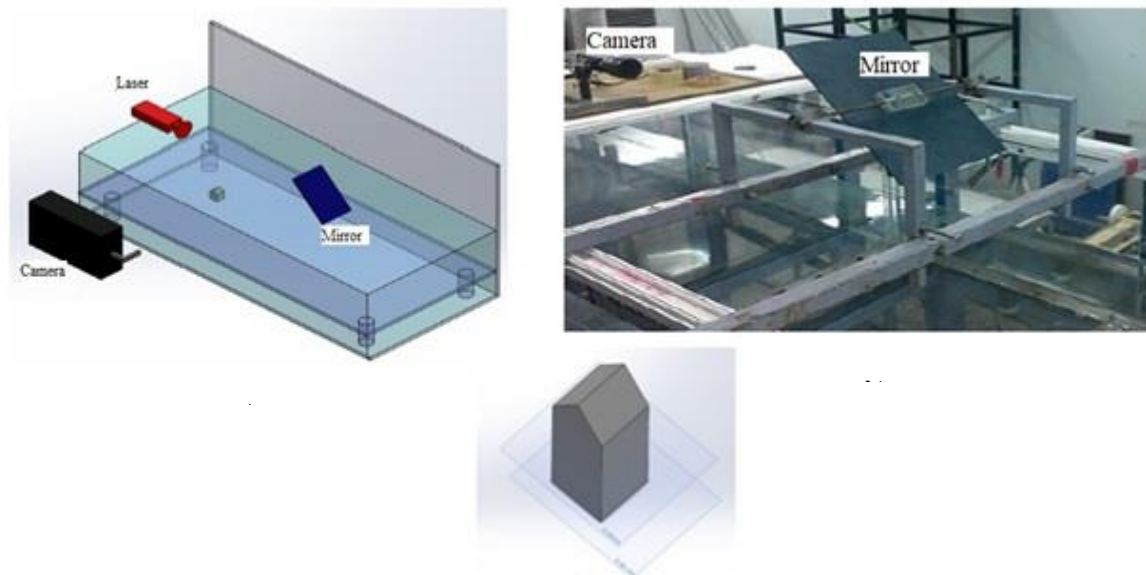


Figure 3. (a) Arranged view of the apparatus for top view (b) Camera and mirror positions for top view (c) Top view measurement surface simulation

Results and Discussion

This study calculated the average velocities of five hundred photographs. Streamlines consist of a series of lines that are the tangents of the local velocity vectors at any given moment. Vorticity is also a measure of the rotation of flow particles. Vorticity values for each measurement surface were determined using the average velocities.

The flow structure formed around the buildings, streamlines $\langle \psi \rangle$, velocity distribution, and dimensionless vorticity contour lines $\langle \omega \rangle$ were obtained from

experimental results. While velocity vectors show the flow distribution and direction in experimental data, streamlines facilitate the understanding of instantaneous flow data. The turbulent boundary layer formed the average equivalent velocity curves. Figures 4(a), (b), (c), and (d) show the schematic experimental placements of buildings placed at a distance from each other and the shape placements of the building model, respectively.

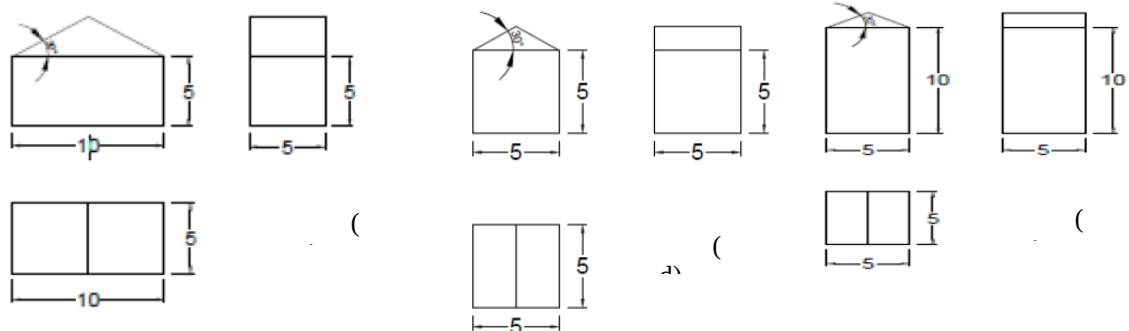
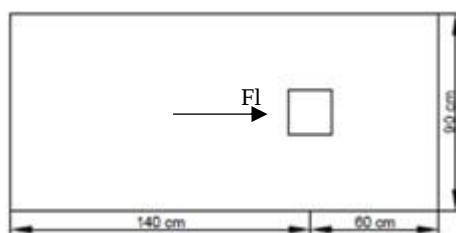


Figure 4. Display of roofed models (a) schematic (b) experimental (c) roofed wide building model (d) roofed short building model (e) roofed long building model

Experimental Results

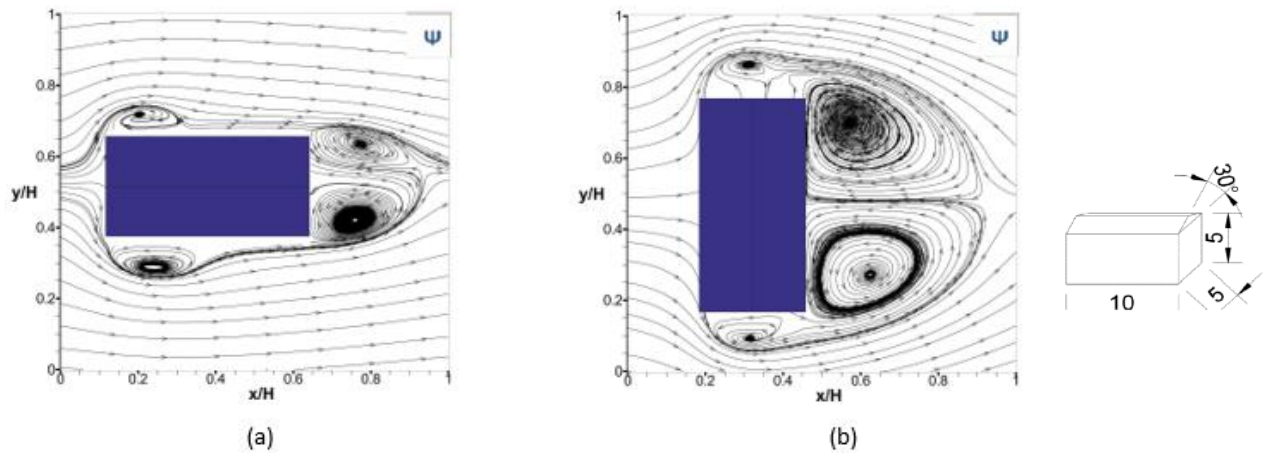


Figure 5. Time-averaged streamlines $\langle \psi \rangle$ on the symmetry plane $y/H = 0.5$ for the flow around the building model with dimensions $10 \text{ cm} \times 5 \text{ cm} \times 5 \text{ cm}$.

Figures 5 (a) and (b) illustrate the streamlines of the flow around a rectangular structure. In Figure 5 (a), the structure is positioned parallel to the flow direction, where the streamlines form a stagnation region at the front of the structure and a distinct separation and recirculation zone behind it. The recirculation region formed at the rear of the structure causes the flow to change direction around the body, leading to the formation of two vortex structures. This indicates that the flow accelerates significantly near the corners of the structure and that the pressure distribution becomes unbalanced.

In Figure 5 (b), the structure is rotated 90° , thus becoming perpendicular to the flow direction. In this case, the flow characteristics change significantly, and two large vortex regions form behind the structure. These vortex structures, located in the upper and lower regions, indicate that the flow separates into two main circulation zones after impinging on the surface of the body. Additionally, pressure accumulation increases at the front of the structure, while a wide low-pressure region develops at the rear. This suggests that the flow separation occurs earlier and that the drag force increases in this configuration.

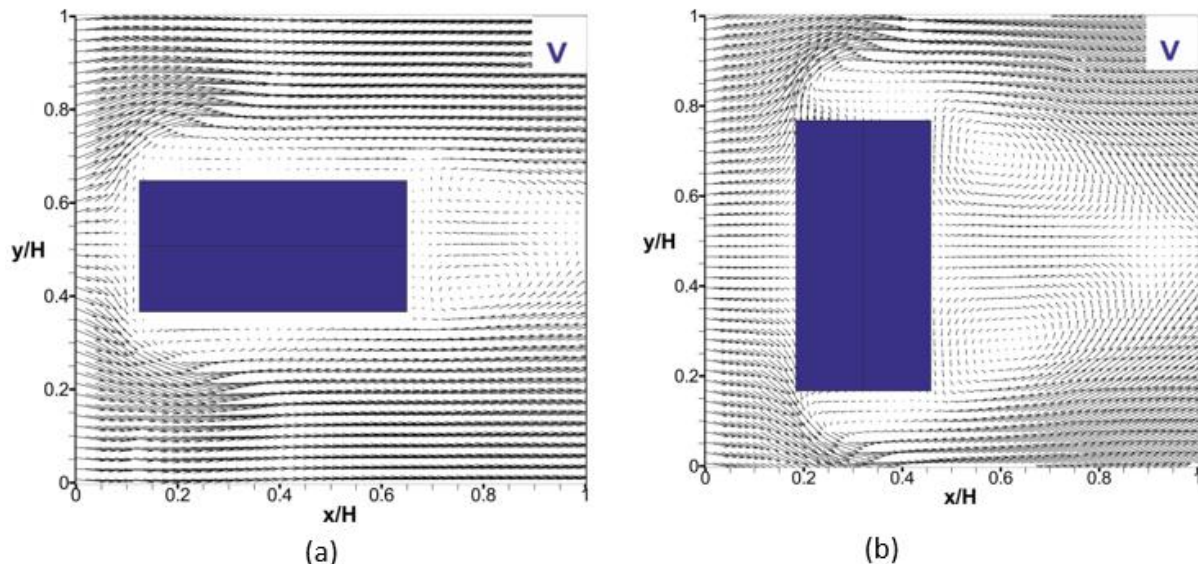


Figure 6. Time-averaged velocity distribution $\langle V \rangle$ on the symmetry plane $y/H = 0.5$ for the flow around the building model with dimensions $10 \text{ cm} \times 5 \text{ cm} \times 5 \text{ cm}$.

Figures 6(a) and (b) illustrate the effects of the orientation of a wide, rectangular-plan building with a roof on the flow characteristics under wind conditions. In Figure 6(a), the long side of the building is positioned parallel to the flow direction, and in this configuration, the streamlines are observed to advance more steadily along the building surface. In this case, the flow forms a limited stagnation region on the front face of the

building and is directed toward the side surfaces without causing large-scale separations. As the flow moves smoothly around the structure, the wake region behind the building develops in a narrow form, and low-velocity gradients are concentrated in localized areas. This indicates that the aerodynamic drag forces acting on the structure are relatively low.

When the building is rotated by 90° , as shown in Figure 6(b), a distinct stagnation region develops on the

broad surface perpendicular to the flow direction, accompanied by abrupt decreases in velocity vectors. Due to the high resistance presented by this surface, the flow undergoes strong deflections in the upward, downward, and lateral directions. As a result of these deviations, the turbulence intensity increases, and flow separation occurs earlier. As the separations grow, a large wake region develops behind the structure, the low-pressure zones deepen, and consequently, the drag component increases significantly. Moreover, distinct vortex structures emerge near the corner regions, which enhance

both temporal and spatial fluctuations within the flow field.

A comparison of both configurations reveals that in Figure 6(a), where the building is oriented parallel to the flow direction, the flow continuity remains more stable, the wake region is narrower, and the turbulence characteristics of the flow are weaker. In contrast, in Figure 6(b), due to the impingement of the flow on a wide frontal surface, pronounced pressure gradients, higher turbulence levels, and a more extensive wake region are observed.

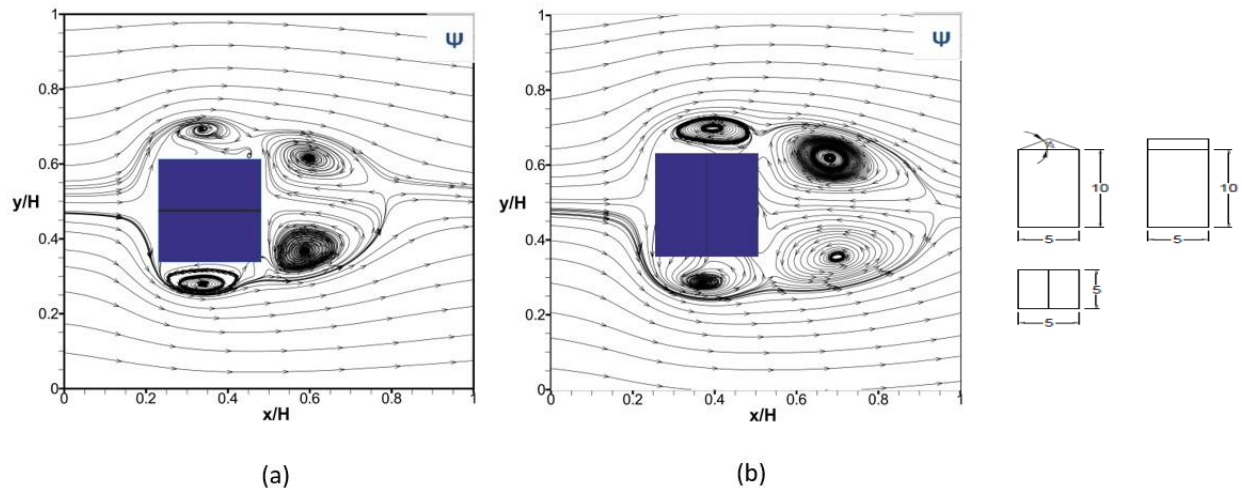


Figure 7. Time-averaged streamlines $\langle \psi \rangle$ on the symmetry plane $y/H = 0.5$ for the flow around the building model with dimensions $5 \text{ cm} \times 5 \text{ cm} \times 10 \text{ cm}$.

Figures 7(a) and (b) illustrate the effects of different orientations of a long building with a square cross-section on the flow structure relative to the flow direction. In Figure 7(a), the short side of the building is positioned parallel to the flow direction. In this case, the streamlines, after contacting the building surface, induce flow separation on both the upper and lower surfaces, resulting in the formation of asymmetric vortex regions behind the structure. The more intense vortical structures observed in the lower part of the building indicate an increase in near-ground turbulence energy. As the flow passes along the side faces of the building, slight deviations are observed, and the wake region appears relatively confined to a narrower area. This indicates that the short building dimension limits the length of the wake region by bringing the flow reattachment point closer to the rear of the building.

In Figure 7(b), the building is rotated by 90° , presenting a wider surface facing the incoming flow. In this configuration, a distinct stagnation region forms at the point where the streamlines meet the building sur-

face, and the flow exhibits sharper deviations both upward and downward. The recirculation zone expands, and multiple vortical structures are observed to overlap within the wake region. The formation of larger-scale vortices, particularly in the upper part of the building, contributes to increased aerodynamic loads and enhances the potential for turbulence-induced structural vibrations. The elongation of the wake region and the increase in vortex density are associated with the abrupt momentum loss of the flow impacting the wide surface, indicating an increase in the drag component.

A comparison of both configurations shows that, in the parallel orientation of the short building, the wake region remains more compact and the vortical structures develop on a smaller scale. In contrast, in the 90° rotated configuration, both the wake length and vortex intensity increase, leading to more complex turbulent structures in the flow field. These results demonstrate that building dimensions and orientation have a critical influence on flow topology, wake characteristics, and the distribution of aerodynamic loads.

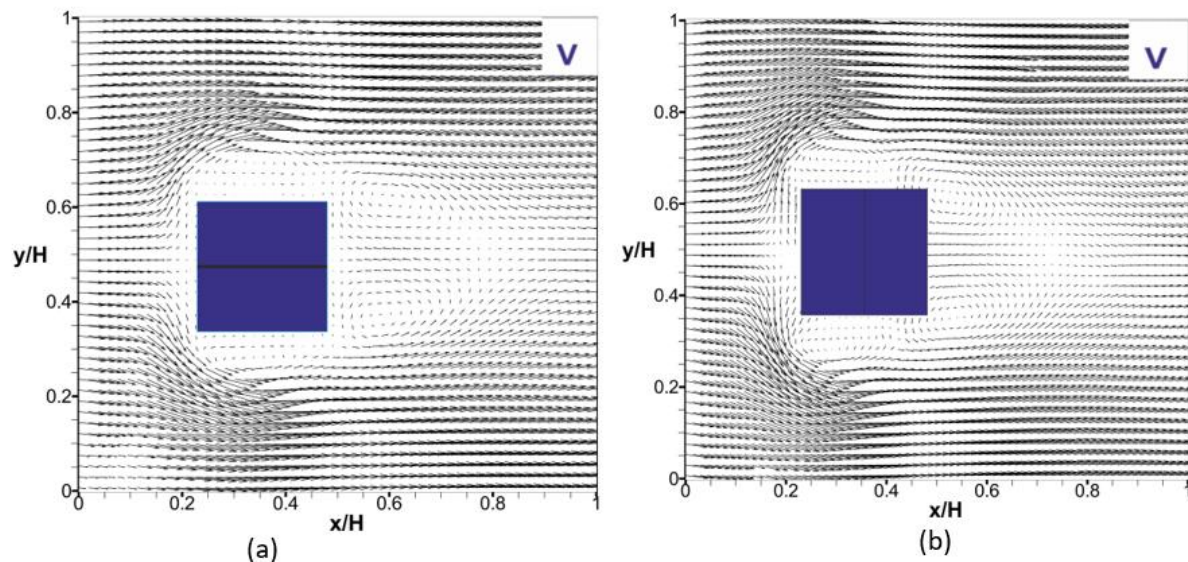


Figure 8. Time-averaged velocity distribution $\langle V \rangle$ on the symmetry plane $y/H = 0.5$ for the flow around the building model with dimensions $5 \text{ cm} \times 5 \text{ cm} \times 5 \text{ cm}$.

Figure 8(a) shows the velocity vector distribution of a square-section tall building model placed in the flow field in its reference position (original orientation). When the flow impacts the front face of the building, a distinct stagnation zone forms, and the flow lines separate around the building, changing direction along the top and bottom edges as the flow continues. Behind the building, a wake region with low velocities is observed. This region is characterized by vortex structures generated as the flow separates from the building's corners.

Figure 8(b) gives the same building model rotated by 90° . In this case, the interaction between the flow and the building changes, and the location and extent of the stagnation zone on the front face differ. The change in building orientation affects the deflection angle of the flow and the symmetry of the wake region behind the building. In the rotated model, the flow lines merge more smoothly, and the turbulence effects in the rear region are somewhat reduced.

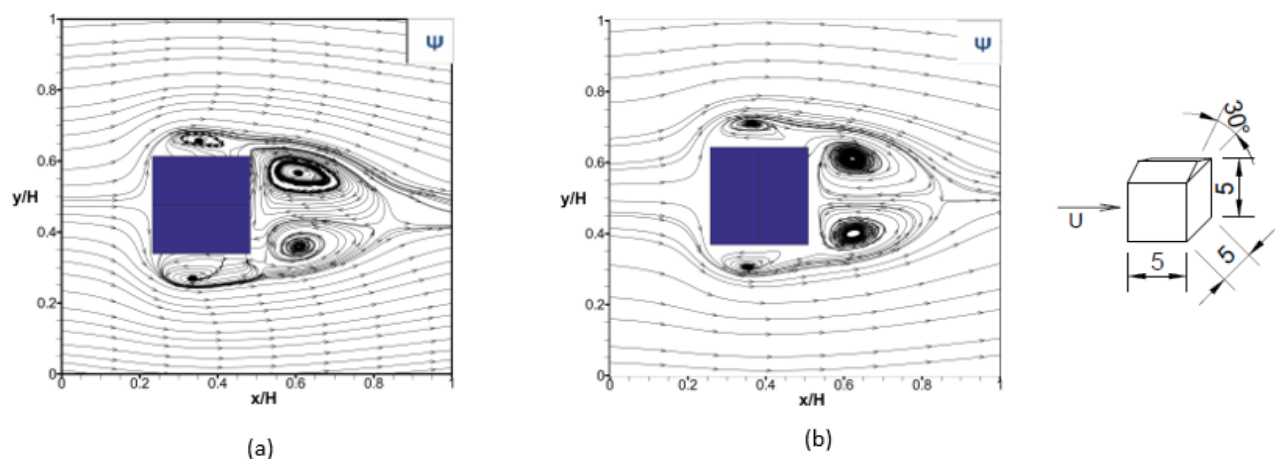


Figure 9. Time-averaged streamlines $\langle \psi \rangle$ on the symmetry plane at $y/H = 0.5$ for the flow around the $5 \text{ cm} \times 5 \text{ cm}$ building model.

Figure 9(a) indicates the streamlines around the square-section short building model. When the flow impacts the front face of the building, flow separation occurs, and a distinct recirculation zone forms behind the building. Within this region, two counter-rotating vortex structures are observed. These vortices, occurring along the top and bottom edges, develop in low-velocity areas after the flow separates from the building. The streamlines in the wake region exhibit a complex

pattern under the influence of these vortices, showing irregular flow characteristics up to the reattachment point.

Figure 9(b) presents the same building model rotated by 90° . In this case, significant changes occur in the distribution of streamlines and the positions of the vortical structures. In the rotated model, the separation regions along the top and bottom edges become more symmetric, and the length of the recirculation zone behind the building is reduced. This indicates that the

flow separates more smoothly from the building, and the turbulence effects in the wake region are relatively diminished.

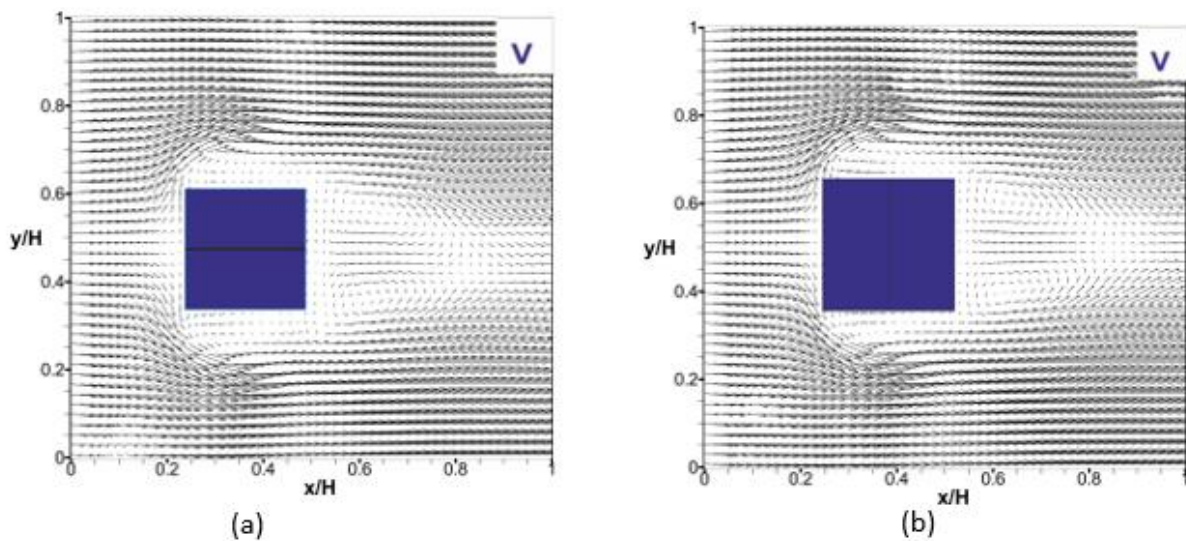


Figure 10. Time-averaged velocity distribution $\langle V \rangle$ for the flow around a building model with dimensions $5\text{ cm} \times 5\text{ cm} \times 5\text{ cm}$, with a symmetry surface $y/H = 0.5$.

Figure 10(a) illustrates the velocity vector field obtained for the reference orientation of the short building model with a square cross-section. When the flow strikes the front surface of the building, a distinct stagnation zone forms, and from this zone onwards, the flow lines are directed around the building, passing through the upper and lower edges. A wake region with low velocities is observed behind the building. In this region, the flow velocity decreases, and recirculating flow with vortex structures is noticeable.

Figure 10(b) exhibits the same building model rotated by 90° . Changing the orientation of the building significantly affects the interaction of the flow with the building surfaces and the locations of the separation regions. In the rotated state, the distribution of the stagnant zone on the front surface has changed, and it can be seen that the flow separation behind the building occurs in a narrower area. This indicates that the flow separates from the building in a more balanced manner and that the recirculation effects in the rear area are reduced.

General Results And Evaluation

1- As the wind impacts and separates around the edges and corners of buildings, recirculation zones develop at the front façades, along the side walls, at the rear, and over the roof regions. Turbulence intensities increase significantly in the shear layers that separate these recirculation zones from the free-stream flow.

2- As one moves from the symmetry axis toward the side edges, the boundary layer thickness decreases, while the jet flow in the downstream region becomes lower in energy. This phenomenon causes the separation region behind the building models to shorten progressively toward the side edges.

3- Regions of high turbulent kinetic energy are formed in the wake vortices behind the buildings, which correspond to the recirculation zones. Moving

downstream from the rear of the buildings, turbulent kinetic energy levels increase near these vortex regions and gradually decrease with distance from them.

4- When the $10\text{ cm} \times 5\text{ cm} \times 5\text{ cm}$ building model is rotated, the vortices formed behind the building increase noticeably in size. Both the width and thickness of these vortices are observed to grow. Furthermore, a significant portion of the flow around the building is affected by these recirculation zones.

5- When the $5\text{ cm} \times 5\text{ cm} \times 10\text{ cm}$ building model is rotated, similar to the $10\text{ cm} \times 5\text{ cm} \times 5\text{ cm}$ model, the vortices formed behind the building become significantly larger, with increases observed in both their width and thickness.

6- When the $5\text{ cm} \times 5\text{ cm} \times 5\text{ cm}$ building model is rotated, no significant changes are observed in the flow characteristics.

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